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PREFERENCE FOR AND TOLERANCE OF THE INTENSITY OF EXERCISE: BRAZILIAN PORTUGUESE ADAPTATION AND VALIDATION, NORMATIVE VALUES, FACTORS ASSOCIATED, AND RELATIONSHIP WITH EXERCISE BEHAVIOR

BRUNO DE PAULA CARAÇA SMIRMAUL

Tese apresentada ao Instituto de Biociências do Câmpus de Rio Claro, Universidade Estadual Paulista, como parte dos requisitos para obtenção do título de Doutor em Atividade Física e Saúde.

Novembro - 2016

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TÍTULO DA TESE: Preference for and tolerance of the intensity of exercise: brazilian portuguese adaptation and validation, normative values, factors associated, and relationship with exercise behavior

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ABSTRACT

Affective responses during exercise are related to exercise adherence and current/future exercise behavior. However, there is large inter-individual variability in affective responses to exercise. Such variability is partly explained by individual differences in preference for and tolerance of the intensity of exercise. Thus, the aims of this PhD thesis were: Article 1 – to adapt the Preference for and Tolerance of the Intensity of Exercise Questionnaire (PRETIE-Q) for the Brazilian population and to perform an initial psychometric evaluation; Article 2 – to test the structural validity of the PRETIE-Q in a diverse population sample and to evaluate its factorial invariance across gender and age subgroups; Article 3 – to explore the factors associated with Preference for and Tolerance of the exercise intensity in a diverse population sample, as well as to provide population-based normative values; Article 4 – to test whether the constructs of preference for and tolerance of exercise intensity are associated to exercise behavior longitudinally in a diverse population sample. For this, the following methods were used: Article 1 – translation and back-translation, production of a Brazilian Portuguese version of the PRETIE-Q, and psychometric evaluation and construct validation using cross-sectional correlations between the Preference and Tolerance scores and physical activity variables; Article 2 – confirmatory factor analysis and a test of multigroup factor invariance of the Brazilian Portuguese version of the PRETIE-Q across gender and age subgroups in a population sample of 622 participants; Article 3 – multiple linear regression between Preference and Tolerance scores with age, gender, BMI and moderate and vigorous leisure-time physical activity (LTPA) in a population sample of 622 participants; Article 4 – multiple linear regressions, partial correlations and multinomial logistic regressions involving demographic and anthropometric variables, as well as exercise behavior from both 2007-2008 and 2014-2015 of 622 participants. The results were: Article 1 – The Brazilian Portuguese version of the PRETIE-Q retained the psychometric properties of the original, demonstrating adequate internal consistency, test-retest reliability, and cross-sectional correlations with physical activity variables among young adults. Article 2 – The Brazilian Portuguese version of the PRETIE-Q retained the structural properties of the original and demonstrated gender and age invariance. Article 3 – among a few significant predictors, only age ($r = -0.348$ and $r = -0.341$) and vigorous LTPA ($r = 0.276$ and $r = 0.140$) were found to be significantly and independently associated with both Preference and Tolerance scores, respectively. In addition, population-based normative values stratified by age categories are presented. Article 4 – controlling for age, gender, BMI and past LTPA levels, a 1-unit increase in Preference and/or Tolerance scores was associated with additional ≈5min/week of total LTPA, ≈2min/week of moderate LTPA and ≈2min/week of vigorous LTPA. In addition, considering the recommended levels of LTPA, a 1-unit increase in Preference and/or Tolerance scores was associated with ≈4-6%, 12.4% and 9.1% greater odds of longitudinally attaining the recommended levels of total, moderate and vigorous LTPA, respectively.

Keywords: Affective Responses. Individual Differences. Intensity-Preference. Intensity-Tolerance.

RESUMO

Respostas afetivas durante o exercício são relacionadas com a aderência ao exercício e com o comportamento atual/futuro de exercício. Entretanto, há grande variabilidade interindividual nas respostas afetivas ao exercício. Tal variabilidade é parcialmente explicada por diferenças individuais na preferência e tolerância da intensidade de exercício. Assim, os objetivos dessa tese de doutorado foram: Artigo 1 – adaptar o Questionário de Preferência e Tolerância da Intensidade de Exercício para a população brasileira e realizar uma avaliação psicométrica inicial; Artigo 2 – testar a validade estrutural do Questionário em uma amostra populacional diversa e avaliar sua invariância fatorial entre subgrupos de sexo e idade; Artigo 3 – explorar os fatores associados com a Preferência e Tolerância da intensidade de exercício em uma amostra populacional diversa, assim como fornecer valores normativos populacionais; Artigo 4 – testar se os constructos de preferência e tolerância da intensidade de exercício são associados com o comportamento de exercício longitudinalmente em uma amostra populacional diversa. Para isso, os seguintes métodos foram utilizados: Artigo 1 – tradução e retrotradução, produção de uma versão do Questionário em Português Brasileiro, e avaliação psicométrica e validação de constructo usando correlações transversais entre os escores de Preferência e Tolerância e variáveis de atividade física; Artigo 2 – análise fatorial confirmatória e teste de invariância fatorial multigrupos da versão em Português Brasileiro do Questionário em subgrupos de sexo e idade em uma amostra populacional de 622 participantes; Artigo 3 – regressão linear múltipla entre os escores de Preferência e Tolerância com idade, sexo, IMC, e atividade física no tempo de lazer (AFTL) moderada e vigorosa em uma amostra populacional de 622 participantes; Artigo 4 – regressões lineares múltiplas, correlações parciais e regressões logísticas multinomais envolvendo variáveis demográficas e antropométricas, assim como o comportamento de exercício tanto de 2007-2008 como de 2014-2015 de 622 participantes. Os resultados foram: Artigo 1 – A versão em Português do Brasil do PRETIE-Q reteve as propriedades psicométricas da versão original, demonstrando adequada consistência interna, confiabilidade teste-reteste e correlações transversais com variáveis de atividade física dentro adultos jovens. Artigo 2 – a versão em Português do Brasil do PRETIE-Q reteve as propriedades estruturais da versão original e demonstrou invariância para sexo e idade. Artigo 3 – dentro alguns preditores significativos, apenas idade (r = -0,348 e r = -0,341) e AFTL vigorosa (r = 0,276 e r = 0,140) foram significativamente e independentemente associadas com os escores de Preferência e Tolerância, respectivamente. Além disso, valores normativos populacionais estratificados por categorias de idade são apresentados. Artigo 4 – controlando por idade, sexo, IMC e níveis passados de AFTL, o aumento em 1 unidade nos escores de Preferência e/ou Tolerância foram associados com ≈5min/semana de AFTL total, ≈2min/semana de AFTL moderada e ≈2min/semana de AFTL vigorosa. Além disso, considerando os níveis recomendados de AFTL, o aumento de 1 unidade dos escores de Preferência e/ou Tolerância foram associados com ≈4-6%, 12,4% e 9,1% maiores chances de atingir longitudinalmente os níveis recomendados de AFTL total, moderada ou vigorosa, respectivamente.

Palavras-chave: Respostas Afetivas. Diferenças Individuais. Preferência da Intensidade. Tolerância da Intensidade.

LIST OF CONTENTS

1. INTRODUCTION

Exercise is medicine (Lobelo, Stoutenberg, & Hutber, 2014), as far as individuals are willing to frequently engage in this behavior in most part of their lives. Although the efficacy of exercise has been demonstrated for over 35 chronic conditions (Booth, Roberts, & Laye, 2012), its health-related effectiveness is severely threatened by the low levels of participation or adherence. In this scenario, physical inactivity has been called "*the biggest public health problem of the 21st century*" (Blair, 2009), and achieving a better understanding of human exercise behavior has become paramount (Bauman et al., 2012).

Current theoretical models of exercise behavior (Biddle & Nigg, 2000; Rhodes & Nigg, 2011) have demonstrated limited success in helping the physical inactivity problem (Ekkekakis, Hargreaves, & Parfitt, 2013a) and, in the last decade, researchers have explored the impact of affective responses on exercise participation and adherence, greatly expanding its understanding and illuminating promising constructs for inclusion on current (or development of new) theoretical models of exercise behavior (Ekkekakis & Dafermos, 2012; Ekkekakis et al., 2013a; Rhodes & Kates, 2015; Williams & Evans, 2014; Williams, 2008). Importantly, affective responses during exercise present large interindividual variability, making the exercise experience pleasant for some and unpleasant (i.e., aversive) for others (for a review see Ekkekakis, Parfitt, & Petruzzello, 2011). In understanding this large interindividual variability, the personality traits of preference for and tolerance of exercise intensity have been particularly encouraging, as they correlate with affective responses during exercise (Ekkekakis, Hall, & Petruzzello, 2005a) and it has been found that, despite similar fitness level and for the same relative exercise intensity, individuals with higher tolerance report more positive affective responses when compared to those with lower tolerance (Tempest & Parfitt, 2016). In this sense, the American College of Sports Medicine (ACSM, 2013), the leading scientific and professional organization in exercise science in the world, has noted that "*measures of individual exercise preference and tolerance could be useful for helping identifying what level of physical activity is appropriate to prescribe for different individuals*" (p. 357).

At present, however, the only available measure of individual differences in exercise intensity preference and tolerance is the Preference for and Tolerance of the Intensity of Exercise Questionnaire (PRETIE-Q) (Ekkekakis et al., 2005a). Such instrument is available only in the English language, impairing its utilization in Brazil. Moreover, several limitations jeopardize the applicability of the ACSM' recommendations and limit the scope of the utilization of the PRETIE-Q for both research and practice in the public health domain: i) apart from college-aged women (Ekkekakis, Thome, Petruzzello, & Hall, 2008), it is unknown whether the factor structure of the PRETIE-Q remains invariant across different population subgroups; ii) there has been no investigation of these constructs in a diverse population sample in terms of age, gender, body mass index, physical activity levels, etc; iii) there has been no investigations of the factors associated with these constructs or population-based normative values in order to use evidence-based parameters to put such information in perspective to provide well-informed recommendations; iv) there has been no investigations on whether longitudinal exercise behavior is associated with such constructs. Hence, the purpose of present PhD thesis was to add to the body of knowledge in this field by addressing these caveats.

2. THESIS' RATIONALE

The present Thesis is based on the following 5 rationale (Figure 1), which will be further developed throughout the literature review:

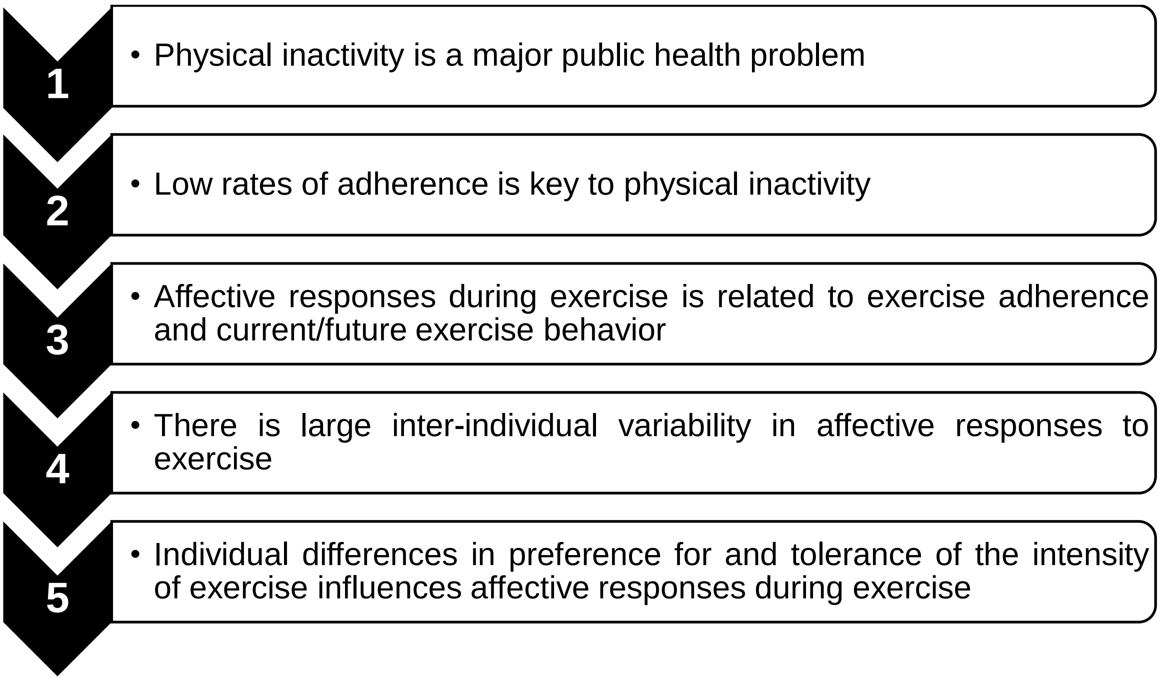

Figure 1 – Rationale of the present Thesis

3. LITERATURE REVIEW

3.1. Physical (In)Activity and Health

3.1.1. Brief History

One of the earliest records of organized physical activity directed to health promotion are from the ancient China around 2500 BC. The history and development of “physical activity and health” also includes Greek philosophers as Hippocrates and Plato, as well as the period of the Roman Empire (MacAuley, 1994). However, it was only in the 19th century that scientific studies associating physical activity and its impact on health started to emerge. Despite the existence of several previous studies indicating such relationship (MacAuley, 1994), the first scientific and systematized epidemiological studies establishing this relationship are considered to be the work by Jerry Morris and colleagues around 60 years ago (Morris, Heady, Raffle, Roberts, & Parks, 1953a, 1953b). For instance, such studies investigated the relationship between physical activity performed at work and the incidence of coronary heart disease in men. Comparing worker groups with distinct levels of physical activity (high: bus conductors and postmen vs. low: bus drivers and telephonists/clerks), the researchers found an inverse association between the level of physical activity and the incidence of coronary heart disease, with lower incidences for the jobs involving higher levels of physical activity (Morris et al., 1953a, 1953b).

Since then, increasing attention has been directed towards the relationship between physical activity and health, leading to pronounced efforts from both researchers and governmental agencies. Influential studies over the years, particularly in the 80s (Powell & Paffenbarger, 1985), substantiated and established this relationship, demonstrating the beneficial effect of physical activity on mortality and longevity (Paffenbarger, Hyde, Wing, & Hsieh, 1986), on coronary heart diseases (Powell, Thompson, Caspersen, & Kendrick, 1987), on psychological health (King, Taylor, Haskell, & DeBusk, 1989), among other health aspects (Haskell, Montoye, & Orenstein, 1985). Since, its creation in 1954, the American College of Sports Medicine, considered the largest sports medicine and exercise science organization in the world, has published the so-called “Position Stands”, in which detailed reviews are performed, integrating scientific research and disseminating it among specialists, professionals and researchers. In 1978, the first “Position Stand” related to the quantity and quality of exercise for developing and maintaining physical fitness in apparently healthy adults was published (ACSM, 1978). To this day, three updates of this review have been published, the first in 1990 (ACSM, 1990), the second in 1998 (ACSM, 1998), and the third and more recent in 2011 (Garber et al., 2011). Also, government agencies around the world have strongly contributed to the area of physical activity and health. Is it noteworthy to highlight the efforts from the World Health Organization (WHO, 2010) and from the high impact US government agency (Physical Activity Guidelines Advisory Committee, 2008; Pate et al., 1995)

3.1.2. Health Impact of Physical (In)Activity

The human body systems (cardiovascular, muscular, metabolic, etc) are evolutionarily adapted to high and frequent physical activity levels (see “*Evolutionary Perspective*” section, especially “*Physical Activity Levels in an Evolutionary Scale*” topic). The drastic reduction of physical activity levels in modern society has caused a negative impact on such systems (Booth, Gordon, Carlson, & Hamilton, 2000; Booth, Laye, Lees, Rector, & Thyfault, 2008). The most recent international guidelines and recommendations, based on an extensive body of scientific evidence, has summarized the impact of physical (in)activity on health. Table 1 summarizes the health benefits of physical activity that, currently, present strong scientific evidence according to international guidelines (Garber et al. 2011; Physical Activity Guidelines Advisory Committee, 2008). The benefits and recommendations are normally subdivided for the populations of children, adults and elderly (WHO, 2010). However, it is worth mentioning that there is scientific evidence for the health benefits of physical activity for a diverse subset of population, such as pregnant women (both during and after pregnancy), specific diseases and conditions as limb loss, multiple sclerosis, spinal cord lesion, cerebral palsy, Alzheimer’s disease, among other (Physical Activity Guidelines Advisory Committee, 2008). Physical activity is believed to provide primary prevention for, at least, 35 chronic conditions (Booth et al., 2012).

Table 1 - Health benefits of physical activity with strong scientific evidence (Physical Activity Guidelines Advisory Committee, 2008; Garber et al. 2011).

Children and Youth	Adults and Older Adults	Persons with Disabilities
cardiorespiratory fitness	all-cause mortality	cardiorespiratory fitness
muscular strength	coronary heart disease	muscular strength
body fatness	high blood pressure	flexibility*
cardiovascular profile	stroke	atherogenic lipids*
metabolic profile	type 2 diabetes	bone mineral density*
bone health	metabolic syndrome	quality of life*
anxiety	colon cancer	
depression	breast cancer	
	depression	
	cardiorespiratory fitness	
	muscular fitness	
	body compositoin	
	bone health	
	sleep quality	
	functional health	
	quality of life	
	risk of falling	
	cognitive function	

* Limited evidence due to the lack of research

An influential study published in the scientific journal The Lancet, estimated that physical inactivity was the cause of around 6-10% of the burden of major chronic diseases and was responsible for more than 9% of premature mortality, or more than 5.3 million of the 57 million deaths worldwide in 2008 (Lee et al., 2012). Specifically, it is estimated that physical inactivity causes 6% of the coronary heath diseases, 7% of the type 2 diabetes, 10% of the breast cancer and 10% of the colon cancer conditions (Lee et al., 2012). Still, while a reduction of 10% in the levels of physical inactivity would prevent half a million deaths annually, the elimination of physical inactivity would increase the world’s population life expectancy in 0.68 years and, only in Brazil, in 1.08 years (Lee et al., 2012).

Indirectly, the physical inactivity negatively influences other health (and economical) aspects, once 1 to 2.6% of all health care costs are attributed to physical inactivity (Pratt, Norris, Lobelo, Roux, & Wang, 2014). Is it estimated that the health care costs related to physical inactivity and its health consequences are around 76 billion dollars in US (Pratt, Macera, & Wang, 2000), 900 million pounds in UK (Scarborough et al., 2011), and 5.3 billion dollars in Canada (Katzmarzyk & Janssen, 2004). Particularly in the state of São Paulo

(Brazil), the costs associated with physical inactivity are estimated in 86 millions of reais (R$) in 2000, representing 3.3% of all public health care costs (Pratt et al., 2014). Maintaining the percentage figure of 3.3%, the total health care costs in 2014 in Brazil would be 3 billions of reais (R$) (considering a total health care cost in 2014 of 91.6 billion of reais). By reducing physical inactivity in 10%, Brazil would save 300 millions of reais (R$) annually, which is actually almost 2 times the amount that the Brazilian government has spent, in total, to promote physical activity over a period of 5 years (170 millions of reais over 2006-2010) (Malta & Barbosa da Silva, 2012; Malta et al., 2014).

3.1.3. Physical (In)Activity Prevalence

The availability of international standardization of research tools enabled the recent acquisition of data from 122 countries around the world (88.9% of the population), resulting in a survey and comparison of overall levels of physical (in)activity (Figure 2) (Hallal, Andersen, et al., 2012). Worldwide, 31.3% of adults are currently considered physically inactive (i.e., < 30 minutes of moderate physical activity per day), with great variability both between different geographic regions, from 27.5% in Africa to 43.3% in Americas, as well as among countries, from 4.7% in Bangladesh to 71.9% in Malta. Still, around 80% of adolescents do not meet the minimum recommended levels of 60 minutes of moderate physical activity daily (Hallal, Andersen, et al., 2012).

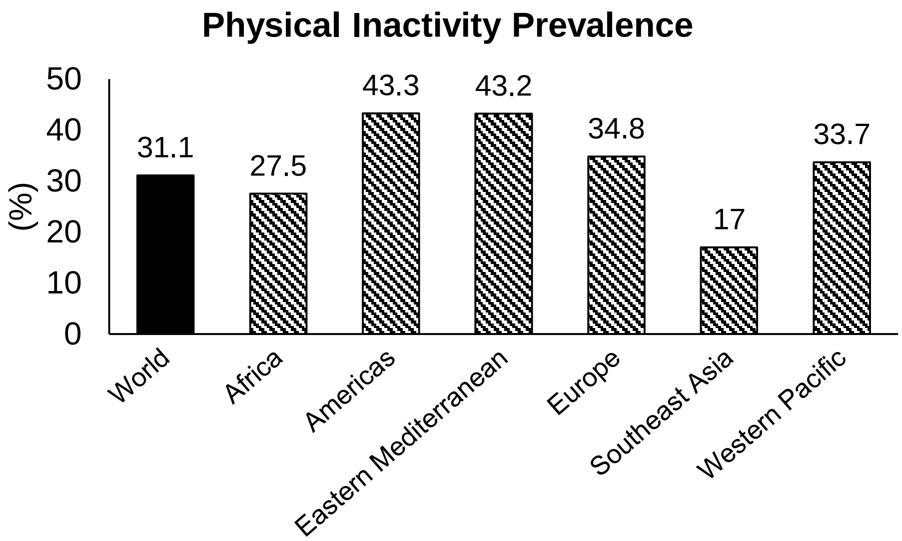

Figure 2 – Physical inactivity prevalence in the world, by regions. Adapted from Hallal and colleagues (Hallal, Andersen, et al., 2012).

It is important to highlight that the physical inactivity levels presented so far have come from studies in which physical activity have been assessed by self-reported measures, usually obtained from questionnaires or diary logs. In 2008, a systematic review compared indirect measures (e.g., questionnaires, diary logs, etc) with direct measures (e.g., accelerometers, doubly-labeled water, etc) of physical activity in adults (Prince et al., 2008). This review showed that, in general, the levels of physical activity are overestimated when self-reported, in comparison to the levels measured by accelerometers. Studies with both men and women (58 studies) resulted in an average difference of 44%, while only with men (32 studies) or only with woman (60 studies) the average differences were 44% and 138%, respectively (Prince et al., 2008). Given such large differences, it is appropriate and educational to investigate the levels of physical inactivity using a direct measure. Using data from the "National Health and Nutrition Examination Survey - NHANES" (Troiano et al., 2008), the physical inactivity levels were determined by means of accelerometers in 2003-2004. The alarming results demonstrated that the prevalence of physical inactivity (not attaining the recommended levels of physical activity) in adolescents, adults and older adults were 94.4%, 96.5% and 97.6%, respectively (Troiano et al., 2008).

3.1.4. Physical (In)Activity and Health in Brazil

Similarly to the international scenario, Brazil has also undergone a significant epidemiological transition over the years, with a reduction in mortality from infectious diseases and an increase in mortality and morbidity from non-communicable diseases (Malta et al., 2009; Malta, Cezário, Moura, Neto, & Silva-Junior, 2006). For instance, of all deaths occurred in Brazil in 1930, while 46% were attributable to infectious diseases, only 11% were due to cardiovascular diseases. By contrast, in 2007, this scenario was reversed, with infectious diseases accounting for only 10% of all deaths, and cardiovascular diseases representing 31%. (Schmidt et al., 2011). Still, while the prevalence of overweight men in Brazil was 18.6% in 1974, this value has reached alarming 50.1% in 2009. Lastly, of all deaths occurred in 2007 in Brazil, 72% are estimated to be caused by non-communicable diseases (Schmidt et al., 2011).

Occurring concurrently and further aggravating the situation in Brazil, approximately 50% of Brazilian adults are considered physically inactive (Hallal, Andersen, et al., 2012; Knuth, Bacchieri, Victora, & Hallal, 2010). Similarly to the international data cited previously (Lee et al., 2012), an investigation with the Brazilian population estimated that physical inactivity causes 3-5% of the major non-communicable diseases and 5.3% of all premature deaths (de Rezende et al., 2015).

In view of the above-described situation, government policies and actions have been implemented in the country, with greater emphasis and resources for primary care, especially through actions of physical activity promotion (Malta et al., 2009, 2006). In 2006, an important step was accomplished within the National Health System, through the approval and implementation of the National Policy of Health Promotion, which ratified the health promotion institutionalization (Malta et al., 2009). Particularly, one of the priorities of this policy is the election of physical activity as a health promotion/protection factor (Malta et al., 2009). In 2008, following these actions, there was the creation of the Support Nucleus for Family Health, which aimed to broaden the range and scope of the primary care actions, as well as to formalize the inclusion of the physical education professional within the National Health System (Malta et al., 2009; Santos & Benedetti, 2012; Vieira, Reis, & Santos, 2010).

Along with the approval and institutionalization of these policies, the Ministry of Health has, since 2005, providing financial support for health promotion actions, especially through physical activity programs (Knuth, Malta, Cruz, Castro, et al., 2010; Knuth, Malta, Cruz, Freitas, et al., 2010). For instance, between the years of 2006 and 2010, the Brazilian government has funded around 171 milions of reais (R$) to approximately 1500 cities, with 70% of them for physical activity promotion actions (Malta & Barbosa da Silva, 2012; Malta et al., 2014). In response to the high-level meeting held by the United Nations in 2011, which discussed the severity of the issue of non-communicable diseases, the Ministry of Health launched, in the same year, the "Strategic Action Plan to Combat Non-Communicable Diseases in Brazil, 2011-2022" (Ministério da Saúde, 2011). Even though this plan comprises several fronts (alcohol, smoking, high blood pressure, diabetes, obesity, etc), the goals and actions related to physical inactivity are highlighted. This Brazilian plan has the goal of increasing the prevalence of leisure-time physical activity from 14.9% in 2010 to 22% in 2022, similarly to the global aim (Malta & Silva Junior, 2013). One of the specific actions of Ministry of Health in the physical activity area was the creation of the "Health Academy" in 2011, which already has transferred funds for the construction of 3725 centers in over 2300 cities in Brazil, targeting 4000 centers by the end of 2015 (Malta & Barbosa da Silva, 2012; Malta et al., 2014; Malta, Dimech, Moura, & Silva Junior, 2013). In terms of physical activity, the "Health Academy" program consists in offering supervised exercise programs at no cost in community settings (Malta & Barbosa da Silva, 2012). Additionally, in order to assess the progress and impact of such policies and actions, several assessment surveys and research have been implemented, as well as specific actions aiming at better qualifying the workforce (Malta et al., 2014).

3.1.5. Physical (In)Activity: Global Challenge

"In view of the prevalence, global reach, and health effect of physical inactivity, the issue should be appropriately described as pandemic, with far-reaching health, economic, environmental, and social consequences". This alarming message stamped the cover page of a special issue of the prestigious scientific journal The Lancet, published in 2012, entirely devoted to the issue of physical inactivity. Named as "*The Lancet Physical Activity Series Working Group",* 33 renowned researchers from 16 different countries joined effort to debate topics such as the impact of global physical inactivity on major non-communicable diseases (Lee et al., 2012), global physical activity levels and tendencies (Hallal, Andersen, et al., 2012), why some people are physically active and other not (A. E. Bauman et al., 2012), etc. Along with other warnings regarding this issue, as the one proposed by Steven Blair in 2009, and reiterated in 2014, by describing physical inactivity as "*the biggest public health problem of the 21st century*" (Blair, 2009; Trost, Blair, & Khan, 2014), and the characterization of physical activity as "*the miracle drug*" (Pimlott, 2010), a global challenge has been launched: "*making physical activity a public health priority*" (Hallal, Bauman, et al., 2012).

3.2. EVOLUTIONARY PERSPECTIVE

3.2.1. Introduction

The famous proposal by Theodosius Dobzhansky that "*Nothing in biology makes sense except in the light of evolution"* implies that 'no meaningful picture as a whole' (p. 129) is achievable if biology is seen out of the light of evolution (Dobzhansky, 1973). This is not to say that scientific advances are not possible without an evolutionary perspective, but rather that its consideration may illuminate previously 'invisible' interpretations (Griffiths, 2009). Investigations using an evolutionary perspective has shed light in a variety areas in biology ranging from (but not limited to) health, medicine, agriculture, conservation biology, natural resource management, and environmental science (Hendry et al., 2011). Particularly in the field of health and disease, and its respective applications in medicine and public health, significant progress has been made due to evolutionary insights (Nesse, Stearns, & Omenn, 2006; Nesse & Stearns, 2008; Stearns, Nesse, Govindaraju, & Ellison, 2010). For instance, one of the main evolutionary learnings is that "*... because biological evolution is* *much slower than cultural change, much disease arises from the mismatch of our bodies to modern environments*" (p. 1691) (Stearns et al., 2010).

For instance, a variety of health conditions, especially chronic diseases, has been proposed as a result of the mismatch between the nutritional and physical activity requirements shaping the human evolution and genetic adaptation for millions of years as hunter-gatherers, and the levels adopted by modern societies (Chakravarthy & Booth, 2004; Eaton et al., 2002; Eaton, Konner, & Shostak, 1988; Konner & Eaton, 2010). Therefore, the low levels of physical activity recently seen in modern society, in contrast to most of human evolution, has affected our evolutionarily programmed metabolic processes, resulting in several chronic diseases (Booth et al., 2008, 2012; Chakravarthy & Booth, 2004). It follows that "*From a genetic standpoint, humans living today are Stone Age hunter-gatherers displaced through time to a world that differs from that for which our genetic constitution was selected.*" (Eaton et al., 1988).

3.2.2. Bipedal Locomotion and the Human Evolution

Is is estimated that the human lineage diverged from the chimpanzees around 5-10 million years ago in East Africa. Based on fossil record, four main stages (Figure 3) in hominin evolution are proposed: I) ≈4-7 million years ago - earliest hominins (genera *Sahelanthropus*, *Orrorin* and *Ardipithecus*); II) ≈4 and 2.7 million years ago - genus *Australopithecus* and genus *Paranthropus robustus*, respectively; III) 1.8-2.5 million years ago - genus *Homo*; and IV) 0.8 and 0.2 million years ago - *Homo heidelbergensis* and anatomically modern humans, respectively (Maslin, Shultz, & Trauth, 2015). Within the human evolution, the emergence of bipedal locomotion and the behavioral adaptations which followed it, such as foraging, scavenging and hunting for more widely dispersed foods and transport it over longer distances (Lieberman, 2011; Lovejoy, 1988, 2009), allowed humans to increase its evolutionary fitness. Thus, the emergence of bipedal locomotion and its consequences are proposed to be key factors that set humans on a separate evolutionary path (Lieberman, 2011).

Initial evidence of the transition from a knuckle-walking to bipedalism of our last common ancestor comes from the fossil record of the *Orrorin tegenensis* 6 million years ago (Richmond & Jungers, 2008). However, the locomotion of this species is still disputed due to the fragmentary nature of the specimens (Maslin et al., 2015). In 2009, however, fossils from the *Ardipithecus ramidus*, a hominid species that lived 4.4 million years ago, provided the most detailed snapshot of early hominid life. This impressive discovery was extensively explored in 11 research articles published in a special issue by *Science* (Alberts, 2009; Hanson, 2009). Briefly, the *Ardipithecus ramidus* reveals the upright origins of humankind, in which its skeleton became progressively modified for bipedalism. The *Ardipithecus ramidus*, which likely lived both on the ground and on top of trees, was a 'facultative' biped (Gibbons, 2009; Lovejoy, Suwa, Spurlock, Asfaw, & White, 2009). The *Ardipithecus ramidus* filled the transition gap existing thus far between the knuckle-walking human-chimp last common ancestor and the adept biped *Australopithecus* (Figure 3). The most famous *Australopithecus afarensis* skeleton, known as "Lucy", was found in 1974 and dated back to 3-4 million years. While the *Ardipithecus ramidus* was a 'facultative' biped, "Lucy" points out to a more habitual walker, with strong evidence of a more efficient bipedality (Kimbel & Delezene, 2009; Lovejoy, 1988). The evolution of bipedal locomotion continued from the *Australopithecus* to the genus *Homo* around 2 million years ago, in which progressive walking and running capabilities further evolved and led to that seen in modern humans (Bramble & Lieberman, 2004). A detailed description of the physiological and anatomical walking/running adaptations in the genus *Homo* can be found elsewhere (Bramble & Lieberman, 2004).

The ability to walk upright was one of the main factors which allowed our ancestors to develop new strategies for acquiring and using energy in times of an environmental transition from woodlands to a more open habitat (as the savannas) around 3 million years ago. These new strategies caused dramatic changes during the evolution of the genus *Homo*, such as a dietary shift involving more meat, reduced guts and teeth, increases in body size and a dramatic increase in brain size (Bramble & Lieberman, 2004; Maslin et al., 2015; Wood & Collard, 1999). In fact, it is believed that these adaptations were possible mainly due to the development of a pronounced walking and running endurance (Bramble & Lieberman, 2004; Lieberman, 2011).

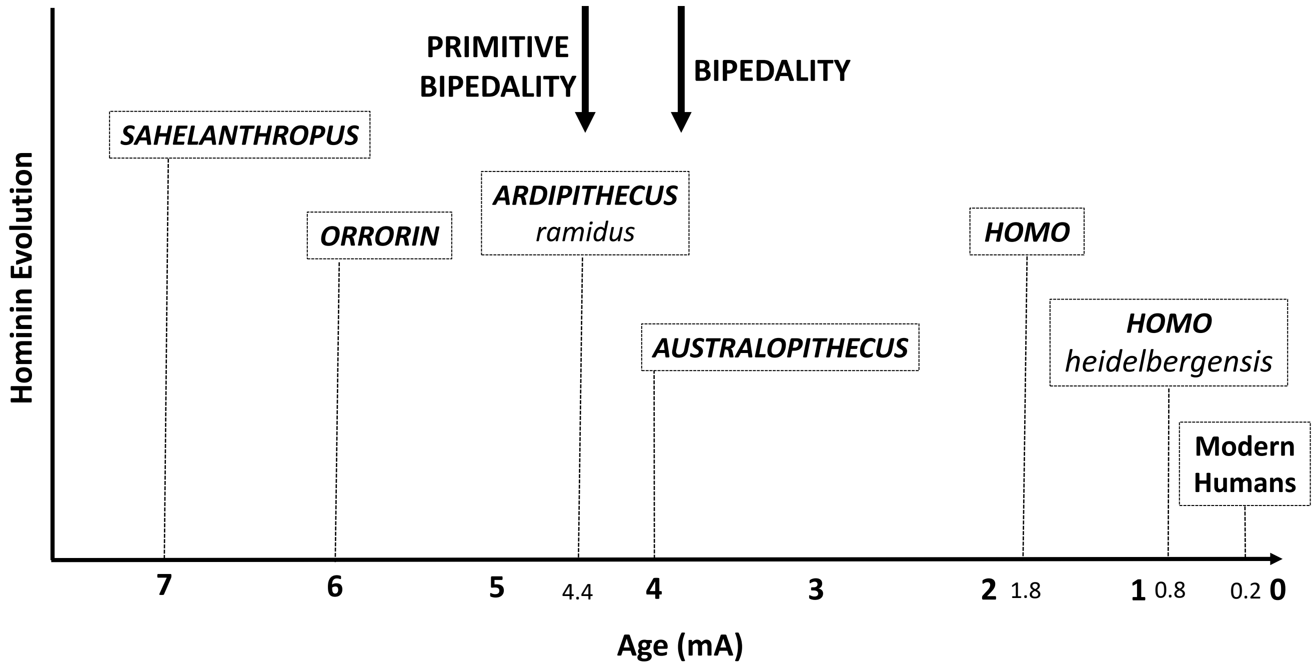

Figure 3 - Key hominin genus/species throughout the hominin evolution and the emergence of bipedalism.

3.2.3. Walking/Running Endurance and the Human Evolution

In a more open environment (savannas) with reduced food availability around 2 million years ago, hominins had to increase their foraging, scavenging, and hunting abilities in order to eat and thus to survive (Lieberman, 2011). Specifically for hunting, hominins were presented a big challenge, as they were small, slow and unarmed compared to their prey animals (Bortz, 1985). However, hominins developed a unique hunting strategy known as persistence hunting. Basically, this strategy consists of walking/running down the prey until it collapses and dies from hyperthermia (Bortz, 1985; Lieberman, 2011). Persistence hunting was only possible due to the exceptional adaptation of the genus *Homo* to endurance walking/running (Bramble & Lieberman, 2004) since the earlier acquisition of bipedal locomotion.

Modern persistence hunting records were identified in various tribes in the last century, such as the Kalahari Bushmen, the Tarahumara Indians of northern Mexico, the Navajo and Paiutes of the American Southwest, and the Australian Aborigines (Carrier, 1984; Liebenberg, 2006; Lieberman, Bramble, Raichlen, & Shea, 2007). Today, however, the only hunter-gatherers known to still practice persistence hunting are specific tribes of the central Kalahari in Botswana and Namibia. A detailed description of field research expeditions conducted from 1985 to 2006 to study these hunters can be found elsewhere (Liebenberg, 2006). Liebenberg (2006) provided a brief description of this hunting method:

"The hunt takes place during the hottest time of the day, with maximum temperatures of about 39–42 C. Before starting, the hunters drink as much water as they can. Then they run up to the animal, which quickly flees, and track its footprints at a running pace. Meanwhile, the animal will have stopped to rest in the shade. The hunters must find the animal and chase it before it has rested long enough. This process is repeated until the animal is run to exhaustion." (p. 1017).

Data recorded during these persistence hunts, irrespective of its success, showed durations ranging from 2h to 6h38min, distances ranging from 17.3-35km, and average speed from 6.3-10km/hr (Liebenberg, 2006). For illustrative purposes, a glimpse of this persistence hunting method can be viewed in the television documentary *The Great Dance: A Hunter's Story* and in the episode *Food for Thought* of the BBC's series *The Life of Mammals*.

The development of a remarkable walking/running endurance in the genus *Homo* (either for foraging, scavenging, or hunting) is proposed as a key feature that significantly accelerated human evolution. Several lines of research propose that these capabilities were the main factor that allowed successful access to higher quality foods (especially meat) which, in turn, allowed for the development of bigger bodies and brains (Bortz, 1985; Bramble & Lieberman, 2004; Carrier, 1984; Krantz, 1968; Lieberman & Bramble, 2007; Lieberman, 2011). In fact, the period around 1.8-1.9 million years ago witnessed the most dramatic increases in brain size (Maslin et al., 2015). Alongside social and ecological selection pressures, an increased aerobic capacity is hypothesized to have had important effects on the evolution of brain size in the genus *Homos*. This hypothesis is supported by the link between aerobic capacity, brain size, neurotrophins and growth factors (Raichlen & Polk, 2013), as well as selection pressures for complex cognitive processes in order to retain and recall information regarding larger areas (Mattson, 2012). In addition, it is currently known that physical activity stimulates the growth of brain cells, the production of new nerve cells in some brain regions, strengthens synapses, and improve cognitive function (Mattson, 2012).

3.2.4. Physical Activity Transition - From Hunter-Gatherers to Modern Societies

Similar to the concepts of epidemiological or demographic transitions, the physical activity levels of the population has undergone a dramatic change, especially in the last century. This change has been characterized by a large reduction of the physical activity levels of the population, and has been called "Physical Activity Transition" (Katzmarzyk & Mason, 2009). For approximately 2 million years, all humans pertained to the hunter-gatherer niche, heavily depending on their physical capabilities in order to survive (obtain food through foraging, scavenging or hunting, water procurement, escape from predators, mobility, etc). It follows that humans spent around 99.99% of their existence undertaking high levels of physical activity (see *Physical Activity Levels in an Evolutionary Scale*). However, after the agricultural, industrial and digital revolutions, humans have been progressively reducing their physical activity levels. In order to visualize this change, as well as its impact on health, we compared the physical activity levels, as well as other health parameters, between modern hunter-gatherers and simple agriculturists with that of modern-technologic societies (Table 2).

As assessing the physical activity levels and other health parameters of our ancestors directly is an impossible task to date, studies investigating modern hunter-gatherers tribes and simple agriculturists, for example, have been used as a proxy for estimating the physical activity levels and health parameters in different lifestyles. The following variables were used: number of steps per day; aerobic capacity; overweight and obesity prevalence; diabetes prevalence; and triceps skinfold measurements. Data from modern hunter-gatherers and simple agriculturists were obtained from a variety of sources (Bassett, Schneider, & Huntington, 2004; Booth et al., 2012; Cordain, Gotshall, & Eaton, 1997; Eaton et al., 1988; O'Keefe, Vogel, Lavie, & Cordain, 2010). Similarly, corresponding data from modern-technologic societies for numbers of steps/day (Bassett, Wyatt, Thompson, Peters, & Hill, 2010), aerobic capacity (Koch et al., 2009; Nunes, Pontes, Dantas, & Filho, 2005), overweight and obesity prevalence (Ogden, Carroll, Kit, & Flegal, 2014; VIGITEL 2015), diabetes prevalence (Guariguata et al., 2014; VIGITEL 2015), and triceps skinfold measurements (Eaton et al., 1988) were retrieved. Mean values for all the variables are shown (Table 2).

Table 2 - Physical activity, fitness and health parameters in modern hunter-gatherers, simple agriculturists and modern-technologic societies.

	Steps/day	VO2max (ml/kg/min)	Overweight Prevalence	Obesity Prevalance	Diabetes Prevalance	Triceps Skinfold (mm)
Modern Hunter-Gatherers	18500	51.8			1.9%	4.5
Simple Agriculturists	16300	63.0	26%	4%	1.2%	6.3
Modern-Technologic Societies	5100	34.5	60%	26%	9.2%	9

Although the transition from hunter-gatherers to agriculturists surely affected our lifestyles, it was only after the industrial and the digital revolution that humans significantly decreased their physical activity levels. Studies have shown both decreases in physical activity levels in the domains related to occupational work, home/domestic work, and travel (transportation), as well as increases in sedentary activities in the last century (Brownson, Boehmer, & Luke, 2005; Ng & Popkin, 2012). The impact of the technological advancements in our lifestyle and its relationship with our physical activity levels can be visualized in an interesting study showing the effects of mechanization in our daily energy expenditure (Lanningham-Foster, Nysse, & Levine, 2003). By comparing activities such as manual vs. machine clothes washing, manual vs. machine dish washing, walking vs. driving to work, and stair climbing vs. elevator riding, the authors demonstrated a reduction in energy expenditure of around 111 kcal/d due to mechanization of these activities. Keeping the same food intake, this would represent a 4.5 kg annual gain in body weight (Lanningham-Foster et al., 2003), not mentioning other health-related problems known to be related to physical inactivity.

The impact of this “Physical Activity Transition” due to technological advancements can be seen ‘live’, as investigated throughout the acculturation process occurred from 1970 to 1990 in an indigenous Inuit population of Igloolik, in Canada. During this 20-year period, they underwent a rapid acculturation to a sedentary lifestyle, moving from hunter-gatherers to a rather modern-technologic society. This transition resulted in a markedly deterioration in fitness of the community, resulting in higher subcutaneous fat, less lean body mass, lower handgrip and leg extension force, and less aerobic power (Rode & Shephard, 1994). In the opposite direction, when the urbanization process was reverted in a group of diabetic Aborigines, which lived for 7 weeks as hunter-gatherers, major abnormalities of type 2 diabetes were either greatly improved or completely normalized (O’Dea, 1984). Among other factors involved in the acculturation process of our modern-technologic society such as food intake, physical activity is believed to play a critical role (Booth et al., 2012).

3.2.5. Physical Activity Levels in an Evolutionary Scale

Since the full development of bipedalism and improvement in walking/running capabilities around 2 million years ago until the agricultural revolution 10.000 years ago, humans pertained to the hunter-gatherer niche, heavily depending on their physical capabilities in order to survive (obtain food through foraging, scavenging or hunting, water procurement, escape from predators, mobility, etc). Despite the agricultural revolution, it was only after the industrial revolution around 200 years ago and, especially after the digital revolution around 50 years ago, that technological advancements allowed humans to become gradually more independent of their physical capabilities on a daily basis. Today, engaging in physical activity is not an obligatory condition for survival, neither is a pronounced requirement in most of our daily routine. Based on a human generation interval of 28 years (Fenner, 2005), it is possible to estimate that humans undergone selective pressures favoring this hunter-gatherer lifestyle for around 71.400 generations. From the agricultural revolution to the present moment, around 350 generations took place, while from the industrial and digital revolution up to now, only 7 and 2 generations, respectively. Moreover, it is possible to calculate that humans spent 99.99% of the previous 2 million years engaging in high levels of physical activity. Only after the industrial revolution (200 years ago) and, especially after the digital revolution (50 years ago), our levels of physical activity significantly started reducing, which means, only in the last 0.01% of the time.

In order to better visualize this discrepancy, the *Cosmic Calendar* method proposed by Carl Sagan in his book *The Dragons of Eden* and on his television series *Cosmos: A Personal Voyage* in 1980 (and in the 2014 sequel series *Cosmos: A Spacetime Odyssey* hosted by Neil deGrasse Tyson) was used. Hence, the 2 million years was condensed down into a single year (Figure 4). Here, the *Cosmic Calendar* will be renamed to *Physical Activity Calendar*. In our *Physical Activity Calendar*, hunter-gatherers humans became heavily dependent upon their physical capabilities to survive at the beginning of January 1 at midnight, and the present moment is mapped at the end of December 31 at midnight. At this scale, there are 3.8 years per minute, 228 years per hour, and 5480 years per day. Thus, our *Physical Activity Calendar* shows that the agricultural revolution (10.000 years ago) took place around 4am of December 30, or 1 day and 20 hours from the end of the year. Similarly, the industrial revolution (200 years) took place around 23pm of December 31, only one hour from the end of the year, while the digital revolution occurred only around 23:47pm of December 31, thirteen minutes from the end of our *Physical Activity Calendar*. As Cordain and colleagues (Cordain, Gotshall, & Eaton, 1998) stated "*The model for human physical activity patterns was established not in gymnasia, athletic fields, or exercise physiology laboratories, but by natural selection acting over eons of evolutionary experience.*" (p. 328).

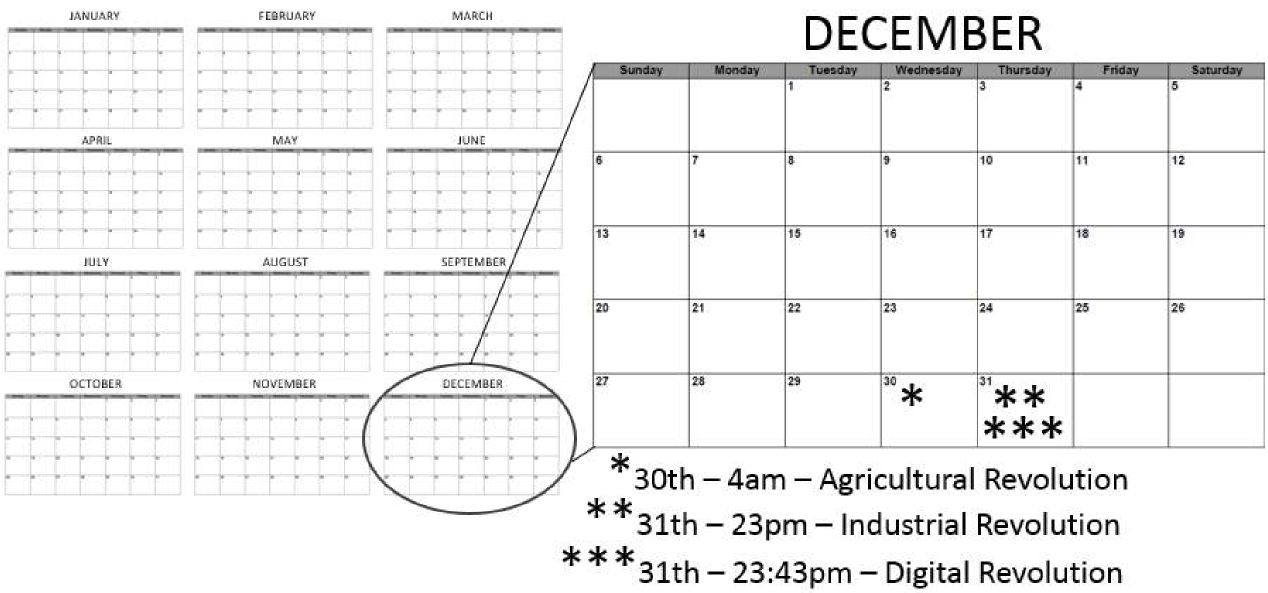

Figure 4 - Physical Activity Calendar.

3.3. Physical (In)Activity Paradox

3.3.1. Fails to increase physical activity levels

Since the pioneer studies from Jerry Morris and colleagues in 1953 (Morris et al., 1953a, 1953b), the scientific investigation regarding the relationship between physical activity and health developed quickly over the following decades (ACSM, 1978, 1990, 1998; Haskell et al., 1985; Powell & Paffenbarger, 1985). Comprehensive actions and campaigns to disseminate public awareness about the benefits of physical activity for health and promote its practice have been held worldwide for decades (Bauman, Smith, Maibach, & Reger-Nash, 2006; Cavill & Bauman, 2004; Centers for Disease Control and Prevention, 1996; Edwards, 2004; Leavy, Bull, Rosenberg, & Bauman, 2011; Marcus, Owen, Forsyth, Cavill, & Fridinger, 1998). As a result of such efforts, recognizing the beneficial effects of physical activity for health has reached a unanimous status today, both for researchers and for government agencies worldwide (Garber et al. 2011; WHO 2010; Physical Activity Guidelines Advisory Committee 2008).

Moreover, such knowledge and recognition also had become widespread among the general population for over a decade. A study conducted in 1999 in the United States showed that >80% of people identified the positive relationship between physical inactivity and development of heart diseases or hypertension (Morrow, Jackson, Bazzarre, Milne, & Blair, 1999). In 2004, in the same country, 94% of people were able to identify the link between a series of physical activities and its relationship with health benefits, and almost 90% indicated "true" to the sentence "*everyone should get 30 minutes of moderate physical activity most days of the week*" (Morrow, Krzewinski-Malone, Jackson, Bungum, & FitzGerald, 2004). Knowledge of the Brazilian population is at equivalent levels. A study published in 2009 showed that knowledge of the adult population on the role of physical activity in prevention and treatment of hypertension was 86.5% and 89.6%, respectively (Knuth et al., 2009). For diabetes, knowledge about the role of physical activity in prevention and treatment were, respectively, 53.8% and 63.1% (Knuth et al., 2009). In addition, 81.4% of people aged 10 or older recognized the association between physical inactivity and acute myocardial infarction (Borges, Rombaldi, Knuth, & Hallal, 2009). Still, a Brazilian population-based study conducted in 2007-2008 with 1596 individuals in the city of Rio Claro, São Paulo, demonstrated that 97.3% of individuals believed that physical activity is beneficial (Sebastião, 2009). In 2014-2015, the follow-up of the aforementioned study, involving 682 individuals, found that 99.1% (n = 676) believed that physical activity is beneficial, as opposed to only 0.9% (n = 6) which does not (unpublished findings).

Even with widespread scientific, government, and public knowledge on the health benefits of physical activity, worldwide prevalence rates of physical inactivity remains elevated. The effort of a "global challenge" to reverse this situation have shown little success over the years, even with comprehensive campaigns and large-scale interventions. Why has this happened? If we ask everyone we know, probably we will find that most of individuals have, at least once in their lives, started an exercise program (either supervised or not). A study involving 50 women with severe physical disabilities showed that 77% of them were already involved in an exercise program sometime in their lives (Rimmer, Rubin, & Braddock, 2000). In addition, only 11% of them had no interest in starting an exercise program, while 82% reported enjoying exercise and 72% that an exercise program would benefit them (Rimmer et al., 2000). Despite the lack of empirical evidence, it is reasonable to speculate that in other populations, especially without physical disabilities, these numbers are even higher.

Thus, only the knowledge of the health benefits and the desire to start an exercise program does not seem to be enough for people to continue participating in exercise programs that they began at some point in their lives. It is essential to emphasize that all the well-known health benefits of physical activity are only relevant if people are involved in this behavior often.

3.3.2. The Dropout/Adherence Problem

A common figure for dropout rates reported in the literature is that 50% of individuals will dropout within a few months after starting an exercise program (Dishman & Buckworth, 1996; Dishman, 1982, 2001). In a review of 18 studies involving either adult fitness (n = 10) or cardiac (n = 18) exercise programs, it was found an average dropout of 46% and 44%, respectively (Franklin, 1988). However, according to the duration of the exercise program, there was considerable variability in dropout rates, ranging from 9% to 87% (Franklin, 1988). In a review of 30 studies comprising exercise in primary and secondary prevention of coronary heart disease, dropout rates ranged from as low as 3% in 36 months to as high as 87% in 12 months (Oldridge, 1982). Still, Ekkekakis has argued that those numbers frequently reported are deceptive (Ekkekakis, 2013). The main reason for such proposition is that they are derived from published clinical trials, usually including some intervention component designed to improve adherence and retention, such as one-on-one counseling, goal-setting, social support, efficacy-building, etc (Ekkekakis, 2013). Outside this research context, it is expected to find even worse adherence values.

For instance, William P. Morgan and Rod K. Dishman reported, in a special edition in the scientific journal "*Quest*" about the topic of adherence to exercise programs and physical activity, that "*The focus of this year's conference [2000 Annual Meeting of the American Academy of Kinesiology and Physical Education*] *represents one of the most significant problems confronting scientists and practitioners in fields such as physical education, kinesiology, public health, and sports medicine today*" (Morgan & Dishman, 2001). Surprisingly, it has been suggested that the dropout problem *"... has not improved since its recognition at least 100 years ago.*" (Dishman, 2001).

Given that almost everyone has (at least once) started an exercise program in their lifetime, it is straightforward to conclude that if adherence to these exercise programs were higher, the issue of physical inactivity and its associated problems would be significantly diminished. In another words, finding a way to have lower percentage of dropouts among individuals starting an exercise program would considerably benefit this public health problem. This exact problem is a challenge that scientists have struggled to further understand in the past decades. The challenge to understand "*why exercisers exercise, and why non-exercisers do not*" remains open, as stated by de Geus and de Moor (2008) and also highlighted by Ekkekakis (2013).

3.4. THEORETICAL MODELS OF EXERCISE BEHAVIOR

3.4.1. Overview

One of the main tools and goals of modern science are the theoretical models. Theoretical models aim to describe the causal relationships responsible for the phenomena of the universe, as well as explain them and predict them. In addition, scientists use theoretical models to deepen their own scientific knowledge and to intervene in reality. Specifically in the area related to human behavior in relation to exercise participation, theoretical models were preceded by correlation studies involving different motivators/barriers/factor for physical exercise participation (Biddle & Nigg, 2000; Rhodes & Nigg, 2011). Some of them are: age, sex, educational level, socioeconomic status, ethnicity, body weight, climate, health status, self-efficacy, motivation, perceived barriers, distance from a fitness facility, esthetics, social support, extraversion, exercise intensity, genetic predispositions, among others (Rhodes & Nigg, 2011). However, despite the usefulness of correlational studies to identify groups of interest (e.g., personal and environmental factors) and to provide directions for future research, they provide no information about the inter-relationship among correlates or a structural order among them. Thus, only theoretical models are capable of adding depth and to be comprehensive enough for a more appropriate understanding of the behavior (Biddle & Nigg, 2000; Rhodes & Nigg, 2011).

Currently, many theoretical models have been proposed in order to explain human behavior in relation to exercise participation. For instance, some of the several models found in the literature are: "Health Belief Model"; "Protection Motivation Theory"; "Theory of Planned Behavior"; "Theory of Interpersonal Behavior"; "Self-Efficacy Theory"; "Locus of Control"; "Self-Determination Theory"; "Transtheoretical Model of Behavior Change"; "Integrated Behavior Change Model" (Biddle & Nigg, 2000; Dishman, 1994; Hagger & Chatzisarantis, 2014; Rhodes & Nigg, 2011).

3.4.2. A need for new exercise behavior models?

Currently, some of the most popular theoretical models applied to understand exercise behavior have been the Theory of Planned Behavior (Ajzen, 1991, 2011), the Transtheoretical Model of Behavior Change (Prochaska & Di Clemente, 1982), and the Social Cognitive Theory (Bandura, 1998). For a detailed description of these theoretical models, the reader is referred to the original articles above and other extensive reviews (Biddle & Nigg, 2000; Dishman, 1994; Glanz, Rimer, & Viswanath, 2008; Rhodes & Nigg, 2011). A common feature that has been consistently present in all above-mentioned theoretical models is the adoption of a cognitivist paradigm, in which decisions are made based on the information collected, the rational analysis of pros and cons, and predictions about the future consequences of the actions, that is, such theoretical models are heavily dependent on cognition and reasoning (Ekkekakis & Dafermos, 2012; Ekkekakis et al., 2013a; Rhodes & Kates, 2015). However, in line with the fact described previously (i.e., that people are largely aware of the health benefits of exercise but are inactive), there are consistent evidence that focusing only on cognitive constructs is not sufficient to increase physical activity levels (Conn, Hafdahl, Brown, & Brown, 2008; Conn, Hafdahl, & Mehr, 2011; Conn, Valentine, & Cooper, 2002).

As pointed out by some researcher, despite the fact that such theoretical models deal with behavior change, they have been borrowed from other health-related disciplines and have not been specifically created to investigate physical exercise (Biddle & Nigg, 2000; Rhodes & Nigg, 2011). For instance, the Transtheoretical Model of Behavior Change was initially proposed in order to investigate smoking cessation (Prochaska & Di Clemente, 1982). Physical exercise behavior, however, presents different characteristics from other health-related behaviors, such as smoking, drinking alcohol, drug use, eating, toothbrushing, flossing, using sun-protection, cancer screening, etc. Rhodes & Nigg (2011) highlight some of these differences: "*PA [physical activity] sets itself apart from other behaviors in that it is an adoption behavior (vs cessation behaviors like smoking, drinking, and drug use), where the 'path of least resistance' or inertia is the absence of the desired behavior; it is not a necessary behavior (vs healthy eating); it requires a significant time commitment (vs toothbrushing, flossing, and sun-protective behavior); physiological response during PA is adaptive, whereas this is a negative sign for other behaviors (stress, alcohol, and drug use); it is not a temporary one-time decision (such as cancer screening and radon testing); and it must be performed above the metabolic equivalent of rest. Thus,* *there is adequate, if not overwhelming, evidence to suggest that unique theories of PA should be pursued”*.

Among the unique characteristics of physical activity behavior proposed by Rhodes & Nigg, perhaps the most relevant in comparison to other health-related behaviors is that physical activity *“places the body in an aversive body state out of homeostasis*” and “*produces variable affective responses that are dependent on the load and temporal aspects of the act*” (Rhodes & Nigg, 2011). These physical activity characteristics have been often overlooked in both theoretical models and exercise prescriptions in the last decades, leading to the question: ‘Will people adopt a behavior that is unpleasant?’ Recently, however, researchers have explored the impact of affective responses on exercise participation and adherence, greatly expanding its understanding and illuminating promising constructs for inclusion on current (or development of new) theoretical models of exercise participation (Ekkekakis & Dafermos, 2012; Ekkekakis et al., 2013a, 2011; Ekkekakis, 2013; Petruzzello, 2012; Rhodes & Kates, 2015; Williams, 2008).

3.5. HEDONIC THEORY

3.5.1. Overview

According to the *Encyclopedia of Sport and Exercise Psychology*, hedonic theory (or theory of psychological hedonism) “*is the idea that human behavior is motivated by the pursuit of pleasure and the avoidance of pain (or, more accurately, displeasure)*” (p. 334) (Ekkekakis, 2014). Hedonic theory has also been described as encompassing "*all theoretical models that explain behavior as a function of its affective consequences or anticipation of its affective consequences*" (Williams, 2008). Michael Cabanac, perhaps one of the most influential modern research on this topic, argued that "*It is likely that at each instant behavior results from the sum of all sensory pleasures and displeasures. The final choice results from a continuous compromise between these sensory pleasures and displeasures and higher priorities.*" (Cabanac, 1979). Based on several evidence of both animals and humans behaviors, pleasure and displeasure has been considered the 'common currency' for accessing behavior (Cabanac, 1971, 1979, 1985, 1992, 2002, 2006; Ramirez & Cabanac, 2003).

Authors have pointed out (Ekkekakis & Dafermos, 2012; Williams, 2008) that hedonic theory has been used extensively in several fields, such as social psychology, behavioral economics, affective neuroscience and experimental physiology, as well as in specific health behavior research, such as in the investigation of obesity and eating, smoking, and substance abuse behaviors. Specific references for such utilizations are provided by these authors (Ekkekakis & Dafermos, 2012; Williams, 2008). In fact, these ideas have been alive for the past 25 centuries. A historical overview tracing a timeline of hedonistic ideas can be found elsewhere (Ekkekakis & Dafermos, 2012). In closing their historical overview, Ekkekakis & Dafermos (2012) stated that "*There have not been empirical findings showing that pleasure and displeasure do not account for meaningful portions of behavioral variance; quite the contrary. The idea has remained standing in the very competitive arena of psychological ideas for over 25 centuries.*"

3.5.2. Hedonic Theory and Theories of Exercise Motivation

"*The problem with the hedonic principle is not that it is wrong but that psychologists have relied on it too heavily as an explanation for motivation*." "*It's time for the study of motivation to move beyond the simple assertion of the hedonic principle that people approach pleasure and avoid pain.*" (Higgins, 1997). By reading these two sentences of E. Tory Higgins, one would think that hedonic ideas are the mainstream paradigm in the field of theories of exercise motivation. Quite the opposite. Although this may be true for other fields in psychology and health behavior (see "Hedonic Theory" section above), the cognitivist paradigm has been dominant in the past decades among exercise scientists. Ekkekakis & Dafermos (2012) have built a case for the fact that, despite several 'missed clues' and 'stumbling blocks' throughout the literature and over the years linking hedonic ideas and exercise behavior, the cognitivist paradigm has reigned as the dominant paradigm leading this scientific field.

3.5.3. Paradigmatic Shift

A recent issue of Psychology of Sport and Exercise published a special section on affective responses to exercise. On its editorial, Ekkekakis, Hargreaves and Parfitt highlighted an undergoing paradigmatic shift in the field of exercise psychology, in which a strong bridge has been built between the traditional and popular cognitivist theories, with the study of affective responses to exercise and its impact on theories of exercise behavior (Ekkekakis, Hargreaves, & Parfitt, 2013b). Arguably, the most prominent researcher leading the paradigmatic shift from traditional (mainly cognitivist) views to recent propositions of the relationship between affective responses and exercise participation has been Prof.

Panteleimon Ekkekakis, who has published several research articles and book chapters on this topic in the last 15 years.

Ekkekakis has argued that "*Perhaps as a result of the frustratingly low percentages of behavioral variance explained by cognitive constructs and the persistent gap between intentions and actual behavior, exercise psychologists are beginning to question the assumption of rationality, as well as to consider possible determinants of behavior beyond the cognitive sphere.*" (Ekkekakis et al., 2013a). Other 'possible determinants' have been mainly affective constructs, such as pleasure/displeasure and enjoyment, and related affective judgements regarding exercise. For instance, a meta-analysis including 82 correlational studies on affective judgement and physical activity indicated a medium to large effect size of 0.42 (95% CI 0.37 - 0.46), which was invariant across measures employed, study quality, population sampled and cultural variables (Rhodes, Fiala, & Conner, 2009). In their discussion, the authors argued that self-efficacy, which is widely regarded as the variable best correlated with physical activity, presents a comparable effect size of 0.35. Additionally, the authors discussed that the effect size found for affective judgements are considerably larger than those usually found for build environment, social, socio-demographic or personality variables (Rhodes et al., 2009). In individuals between 5 and 18 years old, a similar meta-analyses of 56 correlational studies has also found a meaningful medium effect size of 0.26 (95% CI 0.18 - 0.32) for affective judgements and physical activity (Nasuti & Rhodes, 2013). Lastly, Ekkekakis (2013a) has provided several references for studies showing that i) inducing positive or negative affect influences exercise intention; ii) emphasizing the affective benefits of exercise can increase exercise behavior more than emphasizing its benefits for physical health; iii) anticipated positive affective experiences predict future exercise behavior whereas anticipating that exercise will be less pleasant than it actually turns out to be is a predictor of sedentariness (Ekkekakis et al., 2013a)

Evidence that is even more convincing has been provided by a handful of studies investigating the relationship between affective responses and exercise participation. Ekkekakis and Dafermos, in 2012, reviewed 11 studies investigating whether affective responses to exercise are related to exercise participation (Ekkekakis & Dafermos, 2012). In a very similar approach, Rhodes and Kates (2015) performed a systematic review of the literature on the relationship between affective responses to exercise and current or future physical activity behavior. Briefly, the results of these two reviews have provided preliminary evidence for a direct link between affective responses and current/future exercise participation (Ekkekakis & Dafermos, 2012; Rhodes & Kates, 2015). Particularly, the systematic review by Rhodes and Kates (2015) included four studies which assessed basic affect during a session of exercise and its subsequent association with physical activity behavior (Kwan & Bryan, 2010; Schneider, Dunn, & Cooper, 2009; Williams et al., 2008; Williams, Dunsiger, Jennings, & Marcus, 2012). In summary, all four found a significant and positive association between affect during a session of moderate intensity exercise and current or future physical activity behavior, with effect sizes ranging from 0.18 to 0.51 (Rhodes & Kates, 2015). Interestingly, this relationship was found only for affect during, but not after, the exercise session (Rhodes & Kates, 2015).

Lastly, a recent PhD Thesis demonstrated promising results for the link between affective responses and exercise adherence (Freitas, 2014). This study, which involved middle-aged obese women, consisted of an exercising training performed for 12 weeks, 3 times per week. One group performed 30min sessions in a self-selected exercise intensity, while the other group performed 20min sessions in an imposed intensity (110% of the heart rate found at the ventilatory threshold). Results showed that mean affective responses (measured by the Feeling Scale) were 1.4 for the self-selected intensity group and -0.2 for the imposed intensity group. At the end of the exercise program, dropout rates for the self-selected and imposed intensity groups were 12% and 52%, respectively. Additional results of this study can be found in two published articles (Freitas et al., 2014, 2015).

In face of this mounting evidence, Ekkekakis has pointed out that "*the initial blueprints of a 'hedonic' theory of exercise motivation*" is emerging (Ekkekakis et al., 2013a). These initial ideas regarding a hedonic theory of exercise motivation were only possible due to a rather dramatic change and new developments in the theoretical framework behind the exercise-affect relationship, as presented below.

3.6. Affective Responses to Exercise

3.6.1. Affect

The Encyclopedia of sport and exercise psychology defines affect as "*the basic substrate of consciousness, its most elementary constituent*", "*the constant readout of human feeling*" and having a "*distinctive experiential quality that does not consist of nor require cognition or reflection*" (p. 16) (Ekkekakis 2014). Examples of affect are given: pleasure, displeasure, energy or vigor, tiredness or fatigue, tension or distress, and calmness or relaxation. Affect can either be a component of emotions and mood or occur in isolation. For more on the differences between affect, emotion and mood, please refer to Ekkekakis (2012).

The most common conceptualization of affect is a two-dimensional model known as the 'affect circumplex'. The first dimension is pleasure versus displeasure (also called affective valence), while the second dimension if low versus high perceived activation (also called arousal). Thus, affective states can combine pleasure and high activation (energy, vigor), displeasure and high activation (tension, distress), pleasure and low activation (calmness, relaxation), and displeasure and low activation (tiredness, boredom) (Ekkekakis 2014). For several self-reporting measures assessing affect, please refer to Ekkekakis (2012).

3.6.2. Exercise Makes You Feel Better?

An earlier common view was that, in general, exercise makes one feels good (the so-called “feel better” effect). In addition, it was proposed that the relationship between exercise intensity and affective responses would follow an inverted 'U' curve, with moderate intensities eliciting optimal affective responses. However, in 1999, after reviewing 31 studies, Ekkekakis and Petruzzello (1999) found that, while most of the studies did not measure affect during exercise (only before and/or after), the ones which did so demonstrated a decrease in pleasure ratings. That is, the “feel better” effect of exercise was the predominant view not because it was a universal fact throughout the exercise experience (before, during, after), but rather because affect was measured mostly after exercise cessation, rather during it (Backhouse, Ekkekakis, Bidle, Foskett, & Williams, 2007). In 2011, an update of the previous review investigated 33 new studies and consolidated a rather different view from the traditional “feel better” effect (Ekkekakis et al., 2011). Both the inverted ‘U’ curve and the general ‘exercise makes one feels good’ beliefs were challenged (Backhouse et al., 2007).

For illustrative purposes, one of the first study specifically designed to test such hypothesis (universal “feel better” effect of exercise) is presented. In 2000, the study of Van Landuyt and colleagues (Van Landuyt, Ekkekakis, Hall, & Petruzzello, 2000) tested the traditional assumption among researchers and practitioners that moderate-intensity exercise induces positive affective responses in all or most individuals. For this, a homogeneous sample of young, health, and mostly physically active university students were selected to perform a 30min stationary cycling exercise at a moderate intensity (60%

VO2max). Contrary to the traditional assumption, they found a highly heterogeneous response in affective responses, with 44.4% of the participants reporting increases, 14.3% reporting no changes, and 41.3% reporting decreases in affective responses throughout the 30min exercise (Van Landuyt et al., 2000). Since then, the same research group, and others, have provided extensive evidence of this heterogeneous response in the affective responses to exercise (Backhouse et al., 2007; Ekkekakis, Hall, & Petruzzello, 2005b; Parfitt, Rose, & Burgess, 2006; Rose & Parfitt, 2007; Welch, Hulley, Ferguson, & Beauchampc, 2007).

It is important to highlight that these non-conventional results were only found after rebuilding "*the methodological platform*" of the investigations (Ekkekakis & Dafermos, 2012; Ekkekakis, 2005). According to Ekkekakis & Dafermos (2012), the main four changes were: i) using a measurement approach which included both positive and negative affective states; ii) measuring affective states throughout the exercise experience; iii) reducing error variance by standardizing exercise intensity across participants; and iv) analyzing affective states at the level of individuals and subgroups rather than only at the group means level. Ultimately, these findings led to a new theoretical framework to understand the affective responses to exercise: the dual-mode theory.

3.6.3. The "Dual-Mode" Model

In 2003, already faced by preliminary evidence of individual variability and dose-response patterns on the relationship between exercise and affective responses, Ekkekakis proposed a new theoretical framework called "dual-mode" model (Ekkekakis, 2003). Throughout the years, Ekkekakis and colleagues provided a deeper conceptualization of the "dual-mode" model by describing it in more details (Ekkekakis, 2005), providing its basis in evolutionary theory (Ekkekakis et al., 2005b), proposing its putative neural underpinnings (Ekkekakis & Acevedo, 2006), putting it in a metatheoretical context (Ekkekakis, 2009a), and providing its antecedents in psychological theory (Ekkekakis, 2009b). For detailed information regarding each of these characteristics, as well as for empirical evidence supporting the model, the reader is referred to the articles above.

Briefly, the “dual-mode” model “*postulates that affective responses to exercise are determined by the continuous interplay between two factors, namely "top-down" cognitive parameters (e.g., appraisals of physical self-efficacy and self-presentational concerns) and "bottom-up" interoceptive cues (e.g., signals from chemoreceptors, baroreceptors,* *thermoreceptors, mechanoreceptors, and various visceroceptors in the heart, lungs, and internal organs)."* (Ekkekakis & Dafermos, 2012). In fact, the name "dual-mode" comes from the dual influence on affective responses (i.e., cognitive parameters and interoceptive cues) proposed by the model (Ekkekakis, 2003). The relative influence of cognitive parameters and interoceptive cues are theorized to change systematically as a function of exercise intensity, with cognitive factors playing the dominant role in determining the affective responses at intensities below and near the ventilatory threshold (VT), and interoceptive cues becoming the major determinant at intensities that significantly exceed the VT and physiological steady state does not become sustainable (Ekkekakis & Dafermos, 2012; Ekkekakis et al., 2011). The “dual-mode” predicts that i) intensities below the VT will result in mainly positive affective responses; ii) intensities close to the VT will result in quite variable affective responses between individuals; iii) intensities above the VT will result mainly in decreases in pleasure; and that iv) cessation of exercise which induced a decrease in pleasure will result in a positive affective rebound (Ekkekakis & Dafermos, 2012; Ekkekakis et al., 2011). The predictions of the “dual-mode” model have received support not only from several empirical findings (see Ekkekakis et al., 2011), but also have been discussed in light of an evolutionary perspective, in which a homogeneous response in affective states indicates high adaptational significance (light/moderate intensities – benefits vs. strenuous intensities - risks), while a heterogeneous response indicate a trade-off between benefits and risks (mid-range intensities) (Ekkekakis et al., 2005b). Figure 5 illustrates the main aspects of the “dual-mode” model.

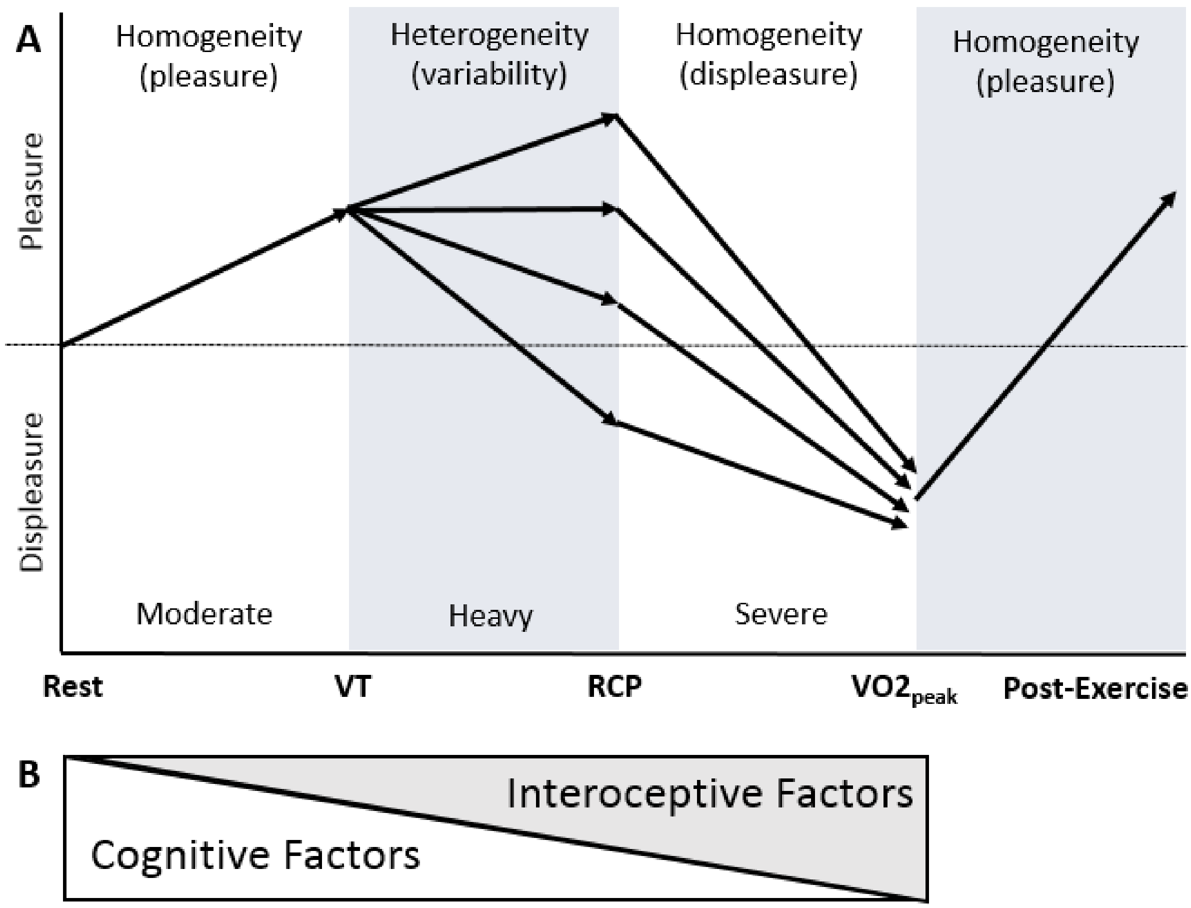

Figure 5 – Illustration of the main aspects of the “dual-mode” model. **A)** Illustration of the general pattern of affective responses to exercise in three intensity domains: i) moderate (homogenous positive response), from rest to ventilatory thresold (VT); ii) heavy (heterogeneous response), from VT to respiratory compensation point (RCP); and iii) severe (homogenous negative response), from RCP to peak oxygen uptake (VO2peak). Also post-exercise there is a homogenous positive rebound in affective responses. Adapted from Ekkekakis (2013). **B)** Illustration of the proposed pattern of the main factors determining affective responses throughout the exercise intensity range. Cognitive factors are proposed as the major determinant at intensities up to the VT, while interoceptive factors become the major determinant in higher intensities.

3.6.4. Individual Variability in Affective Responses to Exercise

The "dual-mode" model predicts two zones of mostly homogeneity (one of pleasure and one of displeasure) and one zone of mostly heterogeneity in affective responses during exercise of varying intensities (Fig. 5). The evidence for both the high level of individual variability in affective responses in some exercise intensities, as well as the evidence for the mostly homogeneous responses in others, have been demonstrated and discussed in a series of studies so far (Backhouse et al., 2007; Ekkekakis et al., 2005b; Parfitt et al., 2006; Rose & Parfitt, 2007; Van Landuyt et al., 2000; Welch et al., 2007). By reanalysing a series of studies, Ekkekakis and colleagues (2005) have provided a summary of the affective responses to exercises at varying conditions and intensities. The affective responses (and its variability) during i) walking at self-selected pace, ii) cycling at a constant intensity, iii) incremental treadmill test to exhaustion (also divided into different phases according to the intensity), and iv) exhaustive cycling under dehydration, can be found of the reanalysis performed by Ekkekakis et al (2005). Ekkekakis and colleagues (2011) have also depicted some of these results in a different format. For illustrative purposes, we selected one these sets of results, at the time (in 2005) unpublished, but which was later published (Ekkekakis, Hall, & Petruzzello, 2008). Figure 6 shows whether affective responses improved, remained stable, or declined when performing three 15min treadmill exercise sessions either below, at or above participant's ventilatory threshold. By the data presented, it is possible to identify some of the predictions from the “dual-mode” model (e.g., greater % of participants showing a decline in affective responses at or higher than the ventilatory threshold in comparison to the intensity below the ventilator thresold), as well as the amount of individual variability in affective responses across exercise intensities (Fig. 6).

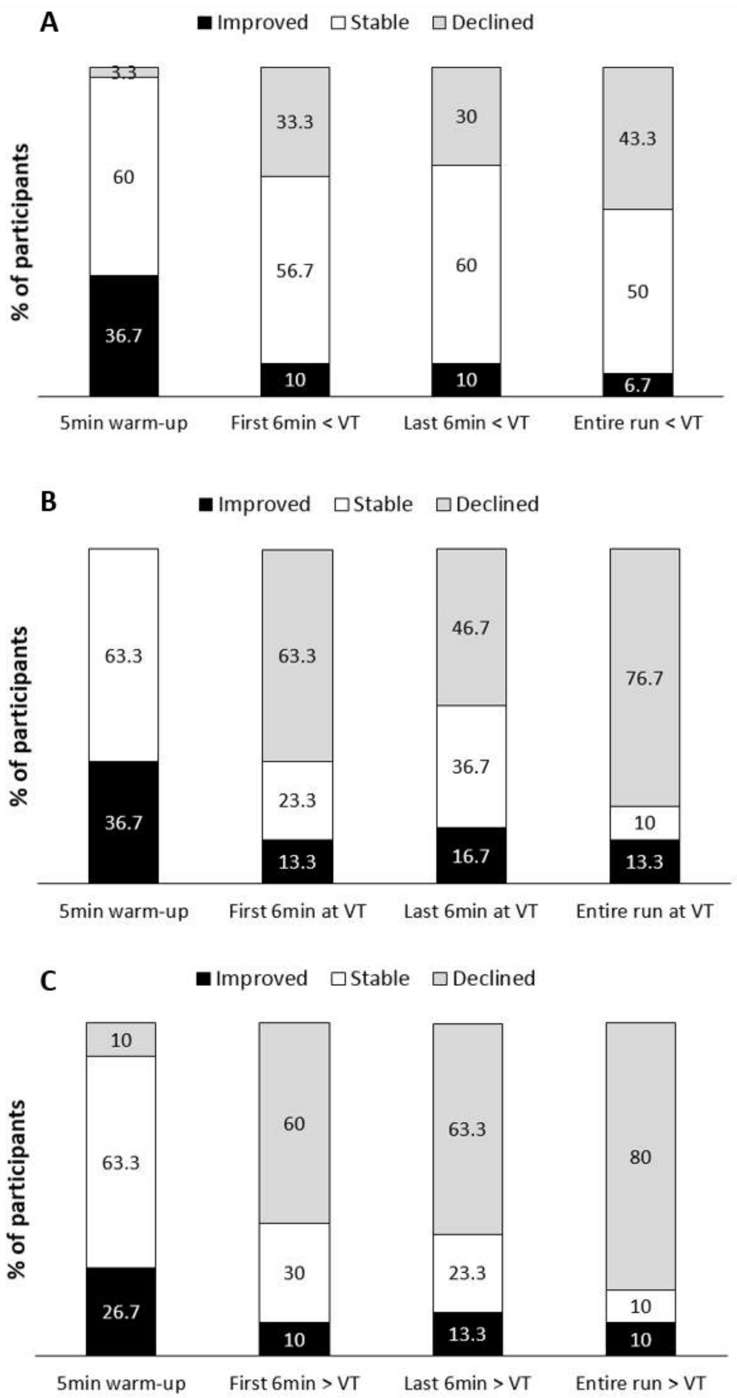

Figure 6 - Percentages of participants reporting an improvement, no change, or a decline in affective responses during 15min treadmill exercise below (A), at (B) or above (C) the ventilatory threshold (VT). Adapted from Ekkekakis et al (2005) and Ekkekakis et al (2008).

3.7. Preference for and Tolerance of the Intensity of Exercise Questionnaire (PRETIE-Q)

3.7.1. Overview

In 2005, the researchers Panteleimon Ekkekakis, Eric E. Hall and Steven J. Petruzzello developed a questionnaire measure of the traits "preference for exercise intensity" and "tolerance of exercise intensity" (Ekkekakis et al., 2005a). The construct of "preference for exercise intensity" was defined as "*a predisposition to select a particular level of exercise intensity when given the opportunity (e.g., when engaging in self-selected or unsupervised exercise).*" On the other hand, the construct of "tolerance of exercise intensity" was defined as "*a trait that influences one's ability to continue exercising at an imposed level of intensity even when the activity becomes uncomfortable or unpleasant.*"

The conceptualization and development of such traits was made, at the time, based on two main lines of evidence. There was evidence of systematic interindividual differences in both the intensity of exercise that individuals choose and in the intensity they can tolerate without a decline in affective valence when that intensity is externally imposed (Ekkekakis et al., 2005a). Alongside these two main points, the concepts of intensity-preference and intensity-tolerance, although probably having a "common-core" with other arousability and sensory modulation traits (e.g., extraversion/introversion), were hypothesized of being primarily associated with interoceptive stimuli from exercise, as opposed to exteroceptive stimuli and behavioral tendencies (primarily social). Importantly, the authors speculated that the preference for and tolerance of exercise intensity traits would be closely linked to affective responses to exercise. Thus, the development of this questionnaire would help understanding the psychological processes that lead to exercise dropout and, then, develop new methods to increase exercise adherence and improve the population's health (Ekkekakis et al., 2005a).

The development of the PRETIE-Q was done through 6 different phases (Ekkekakis et al., 2005a). Phase 1 consisted of an item generation and face validation. Fifteen undergraduate and post-graduate students with extensive exercise experience proposed 5 items for each of the following 4 constructs: i) preference of high exercise intensity; ii) preference for low exercise intensity; iii) high tolerance for intense exercise; and iv) low tolerance for intense exercise. After examination of the proposed items by each of the three researchers (coauthors), 53 items with the highest face validity were selected. Importantly, researchers avoided items that referred to specific modes or amounts of exercise, as well as selecting items that refer to the cognitive evaluation of different exercise intensities. Phase 2 consisted of an exploratory factor analysis and item selection. Items from phase 1 were administered to 287 undergraduate students, in order to identify items that best reflected the underlying latent constructs (highest loadings on the hypothesized factor) and had the clearest factorial identity (lowest cross-loadings). After eliminating items with high loading on the opposite factor from the one originally hypothesized and items with high cross-loadings, 16 items with the highest loadings were selected (4 items for each of the 4 constructs described in phase 1). The final results indicated the presence of 2 factors, with appropriate absolute loadings on the primary and secondary factors. These 16 items were retained as the final form of the questionnaire.

Phase 3 consisted of a structural validity study, in which a confirmatory factor analysis was conducted. For this, the final version (phase 2) was administered to 184 undergraduate students. The results confirmed that the hypothesized 2-factor structure was appropriate. However, when 4 pairs of item (3 from the Preference scale and 1 from the Tolerance scale) were allowed to correlate, the model fit improved considerably. Phase 4 consisted of examination of the internal consistency and test-retest reliability of the PRETIE-Q in samples of undergraduate students. Cronbach's alpha coefficients for the Preference scale ranged from 0.81 to 0.85, while the coefficients for the Tolerance scale ranged from 0.82 to 0.87. The 3-month test-retest reliability coefficients for the Preference and Tolerance scales were 0.67 and 0.85, respectively. Similarly, the 4-month test-retest reliability coefficients were 0.80 and 0.72, respectively. Phase 5 consisted of a test of concurrent validity. For this, the authors compared the responses of the PRETIE-Q with trait measures of arousability and sensory modulation. Overall, weak correlations were found between the PRETIE-Q and other measurements, suggesting the relative independence of the constructs measured by the PRETIE-Q. Lastly, phase 6 consisted of several tests of construct validity (Ekkekakis et al., 2005a).

3.7.2. Validation Studies

Since its development in 2005, a series of studies further investigated the internal consistency, test-retest reliability and construct validity of the PRETIE-Q. A summary of these results are presented for the Preference and Tolerance scales in Tables 2 and 3, respectively. Briefly, both Preference and Tolerance scales have presented high values of internal consistency, ranging from 0.73 to 0.89 (Ekkekakis et al., 2005a; Ekkekakis, Thome, et al., 2008; Hall, Petruzzello, Ekkekakis, Miller, & Bixby, 2014; Lochbaum, Stevenson, & Hilario, 2009), as well as good test-retest reliability, ranging from 0.67 to 0.85 (Ekkekakis et al., 2005a). Tests of construct validity have shown that the Preference scale correlates with self-reported exercise intensity (Ekkekakis et al., 2005a), with affective/enjoyment responses during exercise (Ekkekakis et al., 2005a; Schneider et al., 2009), with self-selected exercise intensity (Ekkekakis, Lind, & Joens-Matre, 2006; Smith, Eston, Tempest, Norton, & Parfitt, 2015), and with self-reported vigorous exercise (Ekkekakis, Thome, et al., 2008). On the other hand, the Tolerance scale has demonstrated correlations with self-reported exercise intensity (Ekkekakis et al., 2005a; Ekkekakis, Lind, Hall, & Petruzzello, 2007), with affective/enjoyment responses during exercise (Ekkekakis et al., 2005a; Schneider et al., 2009), with exercise time persevered beyond the VT/RCP (Ekkekakis et al., 2007, 2006; Tempest & Parfitt, 2016), and with self-reported vigorous exercise (Ekkekakis, Thome, et al., 2008; Lochbaum et al., 2009). Furthermore, both scales have shown to be correlated with physical fitness tests (Hall et al., 2014; Lochbaum et al., 2009), and seem to reflect stable individual differences as no changes were found after a 6-week training program which improved physical fitness (Hall et al., 2014). Lastly, individuals with lower values of self-reported tolerance (mean = 21.1, range 18-24) exhibited more negative affective responses at intensities higher than the ventilatory threshold than those reporting higher tolerance (mean = 33.1, range 30-38) (Tempest & Parfitt, 2016).

Table 3 - Psychometric properties of the Preference scale of the PRETIE-Q

	Ekkekakis et al. 2005	Ekkekakis et al. 2006	Ekkekakis et al. 2008	Lochbaum et al. 2009	Schneider & Graham 2009	Hall et al. 2014	Hall et al. 2014	Smith et al. 2015
Sample	Young Adults	Middle-Aged Women	Young Women	Young Adults	Adolescents	Young Adults	Firefighters	Elderly
Internal Consistency (cronbach's alpha)	0.85 (n = 287) 0.83 (n = 184) 0.81 (n = 64)	-----	n = 601 0.89	n = 286 0.73	n = 146 0.85	n = 516 0.84	n = 42 0.80	-----
Test-Retest Reliability	3 months 0.67 (n = 58) 4 months 0.80 (n = 52)	-----	-----	-----	-----	-----	-----	-----
Correlation with Self-Reported Intensity	0.54 (n = 51) 0.45 (n = 58) 0.32 (n = 143) 0.55 (n = 150)	-----	-----	-----	-----	-----	-----	-----
Correlation with Affective / Enjoyment Responses	n = 30 0.27 - ns (<VT) 0.52 (=VT) 0.16 - ns (>VT)	-----	-----	-----	n = 146 0.22	-----	-----	-----
Correlation with Self-Selected Intensity	-----	n = 23 0.46	-----	-----	-----	-----	-----	n = 17 ≈36% of variance
Correlation with Self-Reported Vigorous Exercise	-----	-----	n = 601 0.21	-----	-----	-----	-----	-----
Correlation with Fitness Tests	-----	-----	-----	-----	-----	n = 516 0.21 - 0.25	n = 42 0.34 - 0.48	-----

ns = nonsignificant correlations; VT = ventilatory threshold

Table 4 - Psychometric properties of the Tolerance scale of the PRETIE-Q

	Ekkekakis et al. 2005	**Ekkekakis et al. 2006**	**Ekkekakis et al. 2007**	**Ekkekakis et al. 2008**	**Lochbaum et al. 2009**	**Schneider & Graham 2009**	**Hall et al. 2014**	**Hall et al. 2014**	**Tempest & Parfitt 2015**
Sample	Young Adults	Middle-Aged Women	Young Adults	Young Women	Young Adults	Adolescentes	Young Adults	Firefighters	Adultos Jovens
Internal Consistency (cronbach's alpha)	0.87 (n = 287) 0.82 (n = 184) 0.86 (n = 64)	-----	-----	n = 601 0.86	n = 286 0.81	n = 146 0.82	n = 516 0.80	n = 42 0.82 - 0.86	-----
Test-Retest Reliability	3 meses 0.85 (n = 58) 4 meses 0.72 (n = 52)	-----	-----	-----	-----	-----	-----	-----	-----
Correlation with Self-Reported Intensity	0.28 (n = 51) 0.49 (n = 58) 0.55 (n = 143) 0.46 (n = 150)	-----	n = 30 0.45	-----	-----	-----	-----	-----	-----
Different Affective Responses between High/Low Tolerance Groups	-----	-----	-----	-----	-----	-----	-----	-----	More Positive Affective Responses at RCP and Exhaustion for High Tolerance Group
Correlation with Affective / Enjoyment Responses	n = 30 0.03 - ns (<VT) 0.40 (=VT) 0.48 (>VT)	-----	-----	-----	-----	n = 146 0.28	-----	-----	-----
Correlation with Exercise Time after the VT/RCP	-----	n = 24 0.38	n = 30 0.43	-----	-----	-----	-----	-----	n = 28 0.48
Correlation with Self-Reported Vigorous Exercise	-----	-----	-----	n = 601 0.36	n = 286 0.17-0.29	-----	-----	-----	-----
Correlation with Fitness Tests	-----	-----	-----	-----	n = 286 0.19-0.24	-----	n = 516 0.21 - 0.36	n = 42 0.35 - 0.56	-----

ns = nonsignificant correlations; VT = ventilatory threshold; RCP = respiratory compensation point

3.7.3. Preference for and Tolerance of the Intensity of Exercise: Calls for Research

For several decades, researches have made calls for the need of more research on the topic of individual differences in preference for and tolerance of the intensity of exercise. Table 5 provides an overview of such calls, emphasizing some of the calls pointing for future research possibilities.

Table 5 - Calls for research on the individual differences in Preference for or Tolerance of the exercise intensity and/or the PRETIE-Q.

Studies	Page	Calls for Research
DISHMAN (1988)	176	"How and when exertion perceptions and preferences develop across the age-span has not been studied"
	187	"When and how do preferences for activity types and intensities develop, and how do they correspond with activity patterns in children and youth and later in adults?"
	424	Recommendations for Research - "Examine when and how preference for types and intensities of activity are formed and how they influence future activity."
EKKEKAKIS et al (2005)	369	"There are also some limitations in the studies reported herein that future work should address." ... "Therefore, we strongly recommend testing the psychometric properties of the PRETIE-Q in other populations (e.g., middle-aged and elderly, physically unfit, low-active, previously sedentary, and patients with exercise-limiting conditions)."
BACKHOUSE et al (2007)	514	"An obvious challenge for future research, and one of potentially great theoretical and practical significance, is the identification of the sources of this variability [affective responses]."
EKKEKAKIS et al (2008)	508	"Essential to this [help tailoring the exercise prescription] process is the establishment of norms (as was done here for college-age women)..."
	509	"Future psychometric investigations of the PRETIE-Q should address some of the limitations of the present study. In particular, the nature of the present sample (i.e. restricted in terms of gender, age, educational level, and socioeconomic status compared with the general population) constitutes an obvious limitation."
	509	"The appropriate next step would be to perform a similar series of analyses with an equally large sample of males and to examine the factorial invariance of the questionnaire across the sexes. Subsequently, a replication with older and more diverse samples with respect to exercise experiences would be highly desirable."
EKKEKAKIS et al (2011)	657	"From a practical standpoint, if the factors that contribute to variability in affective responses are identified, this could spur the development of individually tailored interventions, thus optimizing the exercise experience."

	663	"... directions for future growth based on what we see as key voids in current knowledge." ... "Several recent studies have established that individuals differ in their affective responses to the same exercise intensity. Dissecting the sources of this variability will be perhaps the greatest challenge for researchers in the years ahead."
EKKEKAKIS (2013)	1430	"The presence of interpopulation and interindividual variability [in the relationship between exercise intensity and pleasure] presents challenges and necessitates some radical changes in the way that exercise practitioners are trained (e.g., educational curricula will have to place at least as much emphasis on the psychology of exercise and physical activity as they do on the physiology).

3.8. Cross-Cultural Adaptation

3.8.1. Overview

The number of research tools created to support research in the fields of Exercise Sciences and Health is vast. For instance, consider the number of existing instruments developed to assess physical activity levels. A special issue of *Medicine and Science in Sports and Exercise* has presented a collection of 28 instruments for this purpose (Pereira et al., 1997). However, much of the instruments from the field of Exercise Sciences and Health are developed in the English language, making possible its direct use only in countries with the same cultural background and the same official language (Guillemin, Bombardier, & Beaton, 1993). This fact, combined with the globalization of scientific research and multicentered projects, has encouraged the search for ways to make possible the use of these existing instruments in other countries and/or cultures. In addition to the disadvantages regarding the time and money consumed in the creation of new instruments, the use of existing instruments has many advantages as: i) it provides a common measure for research in different cultural contexts; ii) it offers a standard measure for use in international studies; 3) allows comparisons across countries and/or cultures by means of a standard instrument (Guillemin et al., 1993).

The feasibility of the use of instruments in other languages/cultures to certain target language/culture is by no means a simple process. It is known that if an instrument will be used in a different language and/or culture, one should not just go through the necessary language translation, but also go through a cultural adaptation. This purpose of this process is to maintain the same content validity in the target language and/or culture (Beaton, Bombardier, Guillemin, & Ferraz, 2000). The process which attributes paramount importance to such concerns is commonly called "cross-cultural adaptation". The expression "cross-cultural adaptation" is used to cover the process that examines both the problems of translation as well as the problems of cultural adaptation, when the purpose is to make use of an instrument in another language/culture. This main objective of this process is to achieve the same content equivalence between the original instrument and the instrument in the target language/culture (Beaton et al., 2000). The importance of the process of cultural adaptation has gained increasing attention, not only internationally (Beaton et al., 2000; Gandek & Ware, 1998; Guillemin et al., 1993; Maneesriwongul & Dixon, 2004; Ware & Gandek, 1998; Wild et al.), but also at national level (Giusti & Befi-Lopes; Reichenheim & Moraes, 2007). Such special attention to these processes is essential, since an inappropriate process of translation and cultural adaptation can produce an instrument with inadequate characteristics for the target population (Berkanovic, 1980).

The cultural adaptation, however, may (or may not) be necessary in a variety of situations. Table 5 depicts possible scenarios where there is a change of culture, language and/or country when applying a particular instrument, and what kind of adaptation it requires (Beaton et al., 2000; Guillemin et al., 1993). Comparing the target site (i.e., where one intends to use the instrument) to the source (i.e., where the instrument was developed), different approaches are required (Beaton et al., 2000).

Table 6 - Possible scenarios where some form of cross-cultural adaptation is necessary before utilization of an instrument

	There is a change in...			Adapatation Required	
	Culture	Language	Country of Use	Translation	Cultural Adaptation
Use in same population. No change in culture, language or country	------	------	------	------	------
Use in established immigrants in source countr	X	------	------	------	X
Use in other country with the same language	X	------	X	------	X
Use in immigrants with a different language	X	X	------	X	X
Use in other country with other language	X	X	X	X	X

Adapted from GUILLEMIN et al (1993) and BEATON et al (2000)

As mentioned above, the development of cross-cultural adaptation of an instrument is a complex process, a fact that is accentuated by the lack of consensus among researchers and experts in the field about which methods should be used. A review of methods used for translation and cross-cultural adaptation of research instruments analyzed 47 studies, demonstrating a wide variety of methods used (Maneesriwongul & Dixon, 2004). Moreover, the authors point out the advantages and disadvantages of each method, and recommend the inclusion of a back-translation method, as well as testing among participants from the target language (also called monolingual test), as essential components of an adequate cross-cultural adaptation process (Maneesriwongul & Dixon, 2004).

In order to improve the methods of translation and cultural adaptation of instruments, experts have published recommendations and guidelines (Beaton et al., 2000; Giusti & Befi-Lopes; Guillemin et al., 1993; Reichenheim & Moraes, 2007; Wild et al.). In summary, an adequate process of translation and cultural adaptation should contain 5 stages: 1) translation; 2) synthesis; 3) back-translation; 4) expert committee review; 5) testing.

1) <u>Translation</u> – performed from the source language (original) of the instrument to the target language. It is common to have two or more independent translations;
2) <u>Synthesis</u> – synthetization of the translated versions into the target language, developing a unique version;
3) <u>Back-translation</u> – once having the synthesized version, a translation of the instrument is performed from the target language to the original (source) language;
4) <u>Expert Committee Review</u> – committee comprised of experts, translators and other professionals assess all versions produced up to this point, reaching a consensus regarding a pre-final version;
5) <u>Testing</u> - application of the pre-final version of the instrument to a certain population sample for evaluation, for example, of its degree of understanding and feasibility.

For the process of translation and cultural adaptation of the present study, we used the recommendations proposed by Beaton and coworkers (2000), article that has more than 2564 citations (Google Scholar – 16 Sept 2015). According to the authors (Beaton et al., 2000), these recommendations are also used by the process of translation and cultural adaptation adopted by the project *“International Quality of Life Assessment (IQOLA)”* da *“International Society for Quality of Life Assessment”* (Gandek & Ware, 1998; Ware & Gandek, 1998).

For a high quality of the instrument in the target language and/or culture, some aspects throughout the process of translation and cultural adaptation are important. One of the most important aspects is the concern with the equivalences between the original version and the version in the target language and/or culture. Such equivalences can be divided in i) semantic, ii) idiomatic, iii) cultural and iv) conceptual (Beaton et al., 2000).

Another issue of concern is regarding the content validity of the translated and/or adapted instrument (Polit & Beck, 2006).

Semantic Equivalence - Do the words mean the same thing? Are there different meanings for a particular item? Are there grammatical difficulties in translation?

Idiomatic Equivalence - Colloquialisms or idioms are difficult to translate. There may be the need to formulate an equivalent expression in the target language.

Cultural Equivalence - Items seek to capture and experience of daily life, however, such experience may be not common (or even exist) in different countries and/or cultures.

Conceptual Equivalence - Often words have different conceptual meaning between countries and/or cultures.

Content Validity - degree to which the instrument has an appropriate number of items (or enough information) to the construct under evaluation, and if the content encompasses the purposes of the instrument.

The evaluation of the above-mentioned equivalences is usually performed by a committee of experts in the area, by other related professionals, and by the translators involved. However, all of them must have high proficiency in the source (original) language of the instrument. Regarding the content validity quantification, one of the methods most frequently used has been the "content validity index", based on the assessment of experts in the field regarding the constructs of the instrument (Polit, Beck, & Owen, 2007; Polit & Beck, 2006).

4. PURPOSES

The purposes of this PhD Thesis are presented in 4 different articles, as follows:

Article 1 – To adapt the Preference for and Tolerance of the Intensity of Exercise Questionnaire (PRETIE-Q) for the Brazilian population and to perform an initial psychometric evaluation.

Article 2 – To test the structural validity of the Preference for and Tolerance of the Intensity of Exercise Questionnaire (PRETIE-Q) in a diverse population sample and to evaluate its factorial invariance across gender and age subgroups..

Article 3 – To explore the factors associated with Preference for and Tolerance of the exercise intensity in a diverse population sample, as well as to provide population-based normative values.

Article 4 – To test whether longitudinal exercise behavior is associated with the constructs of preference for and tolerance of exercise intensity in a diverse population sample.

5. ARTICLES

5.1. Article 1 - Preference for and Tolerance of the Intensity of Exercise questionnaire: Brazilian Portuguese version

This article was published in the "*Brazilian Journal of Kinanthropometry and Human Performance*" (http://dx.doi.org/10.5007/1980-0037.2015v17n5p550).

TITLE

Preference for and Tolerance of the Intensity of Exercise Questionnaire: Brazilian Portuguese version

TÍTULO

Questionário de Preferência e Tolerância da Intensidade de Exercício: versão em português do Brasil

SHORT TITLE

Brazilian Portuguese version of the PRETIE-Q

TÍTULO CURTO

Versão em Português do Brasil do PRETIE-Q

AUTHORS

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Abstract - The aim of the present study was to adapt the Preference for and Tolerance of the Intensity of Exercise Questionnaire (PRETIE-Q) for the Brazilian population and to perform an initial psychometric evaluation. The study consisted of two phases: I) translation and back-translation and production of a Brazilian Portuguese version of the questionnaire; and II) psychometric evaluation and construct validation using cross-sectional correlations between Preference and Tolerance scores and physical activity variables. Ratings of semantic, idiomatic, cultural, and conceptual equivalence, as well as total content validity and degree of understanding were adequately high. Response rate was 100% and the average response time was less than 3:30 minutes (204 ± 62 s). Internal consistency coefficients were 0.91 and 0.82, while two-week test-retest reliability coefficients were 0.90 and 0.89 for Preference and Tolerance scales, respectively. Preference and Tolerance scales were significantly correlated with both self-reported intensity (r = 0.48 and r = 0.57, respectively) and frequency (r = 0.40 and r = 0.51, respectively) of habitual physical activity, as well as with the total Godin questionnaire score (r = 0.20 and r = 0.40, respectively) and frequency of strenuous exercise (r = 0.29 and r = 0.49, respectively). The Brazilian Portuguese version of PRETIE-Q retained the psychometric properties of the original, demonstrating adequate internal consistency, test-retest reliability, and cross-sectional correlations with physical activity variables among young adults.

Key words: Exercise prescription; Individual differences; Motor activity; Psychometrics; Translation.

Resumo - O objetivo do presente estudo foi adaptar o Questionário de Preferência e Tolerância da Intensidade de Exercício (PRETIE-Q) para a população brasileira e realizar uma avaliação psicométrica inicial. O estudo consistiu de duas fases: I) tradução, retrotradução e produção de uma versão em Português do Brasil; e II) avaliação psicométrica e validação de constructo através de correlações entre os escores de Preferência e Tolerância e variáveis de atividade física. Equivalências semântica, idiomática, cultural e conceitual, assim como validade de conteúdo total e grau de entendimento foram adequadamente altos. A taxa de resposta foi de 100% e o tempo médio para a resposta foi menor que 3:30 minutos (204 ± 62 s). Os coeficientes de consistência interna foram 0,91 e 0,82, enquanto os coeficientes de confiabilidade teste-reteste de duas semanas foram 0,90 e 0,89 para as escalas de Preferência e Tolerância, respectivamente. As escalas de Preferência e Tolerância foram significativamente correlacionadas com a intensidade autorreportada ($r = 0,48$ e $r = 0,57$, respectivamente) e frequência ($r = 0,40$ e $r = 0,51$, respectivamente) de atividade física habitual, assim como o escore total do questionário Godin ($r = 0,20$ e $r = 0,40$, respectivamente). A versão em Português do Brasil do PRETIE-Q (Apêndice) manteve as propriedades psicométricas do original, demonstrando adequada consistência interna, confiabilidade teste-reteste, e correlações transversais com variáveis de atividade física entre adultos jovens.

Palavras-chave: Atividade Motora; Diferenças Individuais; Prescrição de exercícios; Psicometria; Tradução.

5.1.1. Introduction

Physical inactivity has been called *"the biggest public health problem of the 21st century"*[1]. The Lancet Physical Activity Series Working Group[2] has stated that *"... the issue [of physical inactivity] should be appropriately described as pandemic..."* (cover page). This characterization is supported by population surveys showing that >30% of adults worldwide and >50% of Brazilians reported being less active than the minimum amount recommended for health promotion[3]. This level of inactivity is estimated to cause 6-10% of major non-communicable diseases and 5.3 million premature deaths annually around the globe[4]. A key factor contributing to such high rates of physical inactivity is the low adherence to exercise programs, with dropout rates averaging 50% in the first six months[5,6].

Traditionally, exercise guidelines have been based on a biomedical model. The recommended “dose” of exercise is decided on the basis of only two major considerations, namely (a) the maximization of effectiveness (e.g., improvements in fitness and/or health) and (b) the minimization of risk[7,8]. However, it has become apparent that, even if a guideline is effective and safe, its individual and public health relevance will still be limited unless people are willing to adopt it. This has led to a proposal for a tripartite rationale for exercise intensity prescriptions, incorporating the additional component of affective responses to exercise, such as pleasure and displeasure[7]. This proposal is based on an empirically established positive relationship between affective responses and physical activity participation and adherence[8–10]. Moreover, research has shown that there is large interindividual variability in affective responses during externally imposed exercise intensities, even when intensity is normalized for the fitness level of each individual[7]. These findings have led to calls for a paradigmatic shift from a prescription-based to a preference-based model of exercise promotion[7,9,11], and growing interest in the study of affective responses to exercise[12]. The latest position stand of the American College of Sports Medicine (ACSM) emphasized the importance of considering individual preferences and affective responses during exercise in increasing adherence[13]. Although still emergent, recent investigations support these recommendations, indicating a positive correlation between affective responses during exercise and (both current and future) physical activity participation[9,10], improved affective responses[11] and increased activity participation[14] with self-selected intensity[11], and gains in fitness following an exercise program at an intensity that “felt good”[15].

In order to better understand the large interindividual variability in affective responses during exercise, the Preference for and Tolerance of the Intensity of Exercise Questionnaire

(PRETIE-Q) was developed[16]. The PRETIE-Q consists of two 8-item scales, namely Preference and Tolerance, with each item accompanied by a 5-point response scale. Both scales have demonstrated high internal consistency, from 0.80 to 0.89[16–18], as well as good 3- and 4-month test-retest reliability, ranging from 0.67 to 0.85[16]. Additionally, tests of construct validity have shown that the Preference scale correlates with self-reported exercise intensity[16], affective responses to exercise[16], self-selected exercise intensity[19], and frequency of strenuous exercise[17]. On the other hand, the Tolerance scale has demonstrated correlations with affective responses during high-intensity exercise[16] and the amount of time individuals persevered beyond the intensity of the ventilatory threshold during a graded exercise test[20]. Furthermore, the Preference and Tolerance scales correlated with performance in a variety of physical fitness tests (e.g., sit-ups, 1.5 mile run) and have been shown to reflect stable individual differences, as they remained unchanged despite changes in actual and perceived fitness due to training[18].

The most recent edition of the *ACMS's Guidelines for Exercise Testing and Prescription*[21] states that "Measures of individual exercise preference and tolerance could be useful for helping identify what level of physical activity is appropriate to prescribe for different individuals" (p. 357). Therefore, using the PRETIE-Q to help tailor exercise prescriptions may be a promising way of improving exercise adherence. Particularly in the past few years, Brazil has directed considerable scientific and governmental resources to the challenge of increasing physical activity in the population, especially by implementing physical activity opportunities in community settings[22]. For example, the "Academia da Saúde" ("Health Academy") program, aims to offer supervised physical activity at no cost in 4,000 Brazilian cities[22]. However, millions of reais (R$) may be wasted and the impact of these public policies on health could be jeopardized if exercise participation and adherence remain low. Thus, based on the aforementioned need to better understand interindividual differences in affective responses to exercise, further studies should be carried out involving the promising constructs of preference for and tolerance of exercise intensity. Additionally, application of these constructs by professionals during supervised physical activity classes, such as "Academia da Saúde," may help improve adherence to exercise programs. To date, however, there is no instrument available in Brazilian Portuguese to investigate these constructs. Hence, the purpose of this study was to adapt the PRETIE-Q for the Brazilian population and to perform an initial psychometric evaluation.

5.1.2. Methods

The present study consisted of two phases. The first phase involved the translation and back translation of the PRETIE-Q, with the purpose of producing a Brazilian Portuguese version of the instrument. The second phase consisted of a psychometric evaluation of this version, including construct validation, in a Brazilian sample.

Phase 1. Translation, Back Translation and Production of the Brazilian Portuguese Version

Cross-cultural translation and adaptation were conducted based on the theoretical framework and stages recommended by Beaton and colleagues[23], as seen in Figure 1. These recommendations have been used worldwide and are currently part of the cross-cultural translation and adaptation process adopted by the International Quality of Life Assessment (IQOLA) and by the International Society for Quality of Life Assessment[24].

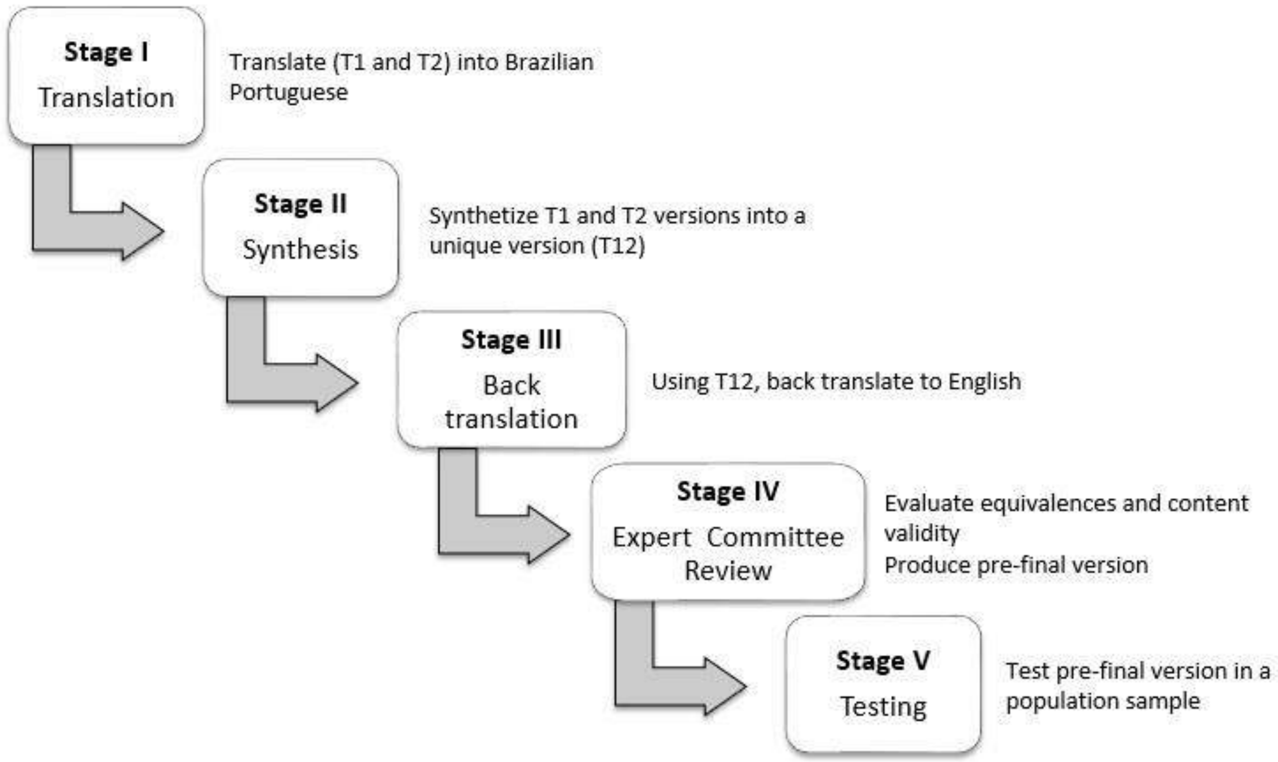

Figure 1. Stages involved in the cross-cultural translation and adaptation followed in the present study. Adapted from Beaton et al.[23].

Firstly, the lead author of the original questionnaire allowed the cross-cultural translation and adaptation of the original PRETIE-Q to Brazilian Portuguese[16]. Then, two forward translations (T1 and T2) were performed from English (i.e., the original language) into Brazilian Portuguese (i.e., the target language). The translators, whose mother tongue was Brazilian Portuguese, produced T1 and T2 independently (*Stage I*). One translator had postdoctoral experience in Physical Education, having lived in an English-speaking country for more than one year and had English proficiency. This translator was aware of the concepts being examined in the instrument. The other translator was a teacher of English who had also lived in an English-speaking country, and was neither aware of the research purpose nor had a background in physical education, exercise science, or related field. Both produced their forward translations in written form. Subsequently, a synthesis of these translations was performed by the authors of the present study by consensus, generating a unique common translation (T12) (*Stage II*). From this unique common translation, one back-translation was performed (*Stage III*) by a native English speaker who had lived in Brazil for several years, thus having mastered Brazilian Portuguese at an advanced level. This person was neither aware of the research purpose nor had a background in physical education, exercise science, or related field. This back-translation was then sent to the lead author of the original questionnaire[16], who provided feedback and additional semantic suggestions.

The semantic, idiomatic, cultural, and conceptual equivalence of items (*Stage IV*) was evaluated by two physical education specialists, one with postdoctoral degree and the other with master's degree, as well as by the two forward translators. This equivalence was evaluated for title, instructions, and for each of the questionnaire items. Evaluators were provided with specific instructions regarding semantic, idiomatic, cultural, and conceptual equivalence based on recommendations of Beaton et al.[23]. A 4-point response scale was used (1 = not equivalent, 2 = requires major alterations to be equivalent, 3 = requires minor alterations to be equivalent, 4 = equivalent). If any item received score of 1 or 2, additional review of this item was performed.

The content validity was quantified by the content validity index (CVI)[25]. Evaluation was performed by a panel of three physical education specialists (with master's degree or higher). They were instructed to refer to whether the items, and the instrument as a whole, measured the intended concepts and met the questionnaire objectives, based on the definitions found in Polit and Beck[25]. A 4-point response scale was used (1 = not relevant, 2 = somewhat relevant, 3 = quite relevant but needs minor alteration, 4 = very relevant). Firstly, 17 partial CVIs were calculated (for each of the 16 items and for the questionnaire as a whole) by dividing the number of evaluators giving a 3 or 4 for each of the 17 ratings by the number of evaluators. Then, the mean value of these partial CVIs was calculated to obtain the total CVI.

With all the aforementioned documents completed, a final consolidation was conducted by a committee of experts, consisting of the study authors and the forward and back translators, producing the Brazilian Portuguese version of the questionnaire. The Brazilian Portuguese version was then tested in a sample of native Brazilian responders (*Stage V*). The PRETIE-Q consists of two 8-item scales, namely Preference and Tolerance, in which each item accompanied by a 5-point response scale. The Preference scale contains four items that measure preference for high intensity (Items 6, 10, 14, 16) and four that measure preference for low intensity (Items 2, 4, 8, 12). Similarly, the Tolerance scale contains four items that measure high tolerance (Items 5, 7, 11, 15) and four that measure low tolerance (Items 1, 3, 9, 13). Items indicative of preference for low intensity (Items 2, 4, 8, 12) and items indicative of low tolerance (Items 1, 3, 9, 13) are reversed-scored. Thus, the possible score range for each scale is 8 - 40.

Phase 2. Testing of Brazilian Portuguese Version

Subjects

The psychometric evaluation of the Brazilian Portuguese version of the questionnaire was conducted by applying it to a sample of 66 undergraduate students (2^{nd} and 3^{rd} years), comprising 41 men and 25 women. The construct validity tests[17,19] were conducted with the original 66 respondents and an additional sample of 56 undergraduate students (a total of 122 individuals). Physical Education undergraduate students (n = 80) and other undergraduate courses (n = 42), were invited to participate through announcements made at the beginning of a class period, with the consent of the respective instructors. After detailed explanation of procedures, participants immediately started responding the survey, which was administered in groups. All participants signed an informed consent form describing the study procedures, which had been approved by the local Ethics Committee (n. 430.908) according to the standards set by Resolution 466/12.

Procedures

The respondents rated their degree of understanding of the instructions and each of item of the Brazilian Portuguese version of the questionnaire. Instructions and each item were accompanied by a 6-point Likert-like response scale (0 = I did not understand anything, 1 = I understood a little, 2 = I understood so-so, 3 = I understood almost everything, but I had some doubts, 4 = I understood almost everything, 5 = I understood perfectly and I do not have any doubts). Response rate was evaluated by the total number of refusals, both to answer the entire questionnaire and for each individual item. Response time was evaluated by administering the Brazilian Portuguese version of the PRETIE-Q to 33 undergraduate students, who were completing the questionnaire for the first time. Response time was measured in minutes and seconds using a chronometer. The questionnaire was administered again after a 2-week interval.

The survey included basic demographic and anthropometric information such as age, weight, and height. The frequency and session duration of habitual physical activity, as well as the duration of lifetime involvement in physical activity, were also assessed. Frequency was assessed by the question "How many days (on average) do you exercise per week?" Session duration was assessed by the question "How long (on average) do you exercise per session?" (in minutes). Duration of lifetime involvement was assessed by the question "How long have you been exercising on a regular basis (at least 3 times per week)?" (in years and months, later converted to months)[19].

Construct validity was evaluated by examining the cross-sectional relationship of the scores on the Preference and Tolerance scales with the self-reported intensity of habitual physical activity. Self-reported intensity of habitual physical activity was assessed by a modified form of Borg's Category Ratio 10 scale[26]. The Godin Leisure-Time Exercise Questionnaire[27] was also used. It includes three questions inquiring about the number of times, during a typical 7-day period, the respondent performs strenuous, moderate, or mild exercise. Weekly frequencies are multiplied by 9, 5 and 3 for strenuous, moderate, and mild exercise, respectively, to calculate a composite "total leisure activity score". The questionnaire also includes one item inquiring about the number of times, during a typical 7-day period, the respondent is engaged "in any regular activity long enough to work up a sweat (heart beats rapidly)". For this study, the version of the Godin questionnaire recently adapted for the Brazilian population was used[28]. The reliability and validity of studies on the Godin Leisure-Time Exercise Questionnaire are summarized elsewhere[27]. Three groups were formed based on whether respondents reported their highest frequency of participation in strenuous (n = 24), moderate (n = 41), or mild exercise (n = 36). Participants who reported an equal number of times per typical week for two or more intensity domains were excluded. Similarly, three groups were formed based on how often respondents are engaged in "any regular activity long enough to work up a sweat (heart beats rapidly)" during a typical 7-day period" (rarely/never, n = 23; sometimes, n = 39; often, n = 60).

Statistical Analysis

Descriptive statistics (means, standard deviations, frequencies, and ranges) was used to describe the participants' characteristics. The sample size was calculated based on the recommendations by Beaton et al.[23] for cross-cultural adaptations of psychometric instruments (i.e., at least 30 participants). Moreover, the sample size of 122 provides sufficient statistical power to detect a 6.25% variance overlap between two correlated variables (r = 0.25), assuming a two-tailed test of significance, alpha of 5%, and 1-beta of 80%. The internal consistency of the Preference and Tolerance scales was assessed by Cronbach's alpha coefficient. Test-retest reliability (2-weeks) was examined using the intraclass correlation coefficient and associated 95% confidence intervals (CI) for the Preference and Tolerance scales, as well as for each individual item. The Pearson correlation coefficient was used to assess corrected item-total correlations, as well as the associations of the Preference and Tolerance scores with habitual physical activity variables and the Godin questionnaire scores (leisure-time exercise habits). One-way analysis of variance (ANOVA) was conducted to compare the Preference and Tolerance scores between groups reporting a higher prevalence of participation in strenuous, moderate, or mild exercise and the groups reporting how often they perform “any regular activity long enough to work up a sweat (heart beats rapidly)” (from the Godin questionnaire). In case of significant omnibus test, Bonferroni-adjusted post hoc tests were performed for pairwise comparisons. Effect sizes are reported as partial eta squared (η^2), calculated as: sum of squares between groups / total sum of squares. Cases in which the participants left a question unanswered are denoted with a different *n* value. Significance was set at $P < 0.05$ (two-tailed) for all analyses.

5.1.3. Results

Translation, Back Translation and Production of the Brazilian Portuguese Version

Minor disagreements between the translators were resolved by consensus for the generation of the unique common forward translation. After back translation was completed, the lead author of the original questionnaire[16], as well as the expert committee, provided valuable suggestions. On item 3, the expression "breathing very hard" was back-translated as "difficulty breathing". As this latter expression may be interpreted as a pathological symptom (e.g., asthma, COPD), item 3 was reviewed and modified from "*respirando com dificuldade*" to "*respirando com muito esforço*". Item 10 was back translated to "does not interest me". As "interest" has a somewhat different meaning in Brazilian Portuguese, item 10 was reworded from "*não me interessa*" to "*não me agrada*". Item 15 was back-translated as "force myself" and subsequently changed from "me esforço" to "continuo," to better reflect the original meaning.

The evaluation of the semantic, idiomatic, cultural, and conceptual equivalence of the title, instructions and each of the 16 items resulted in mean values ranging from 3.75 to 4.00 (on a scale from 1.00 to 4.00). All equivalences were scored by evaluators as 3 or 4 (none of them was scored 1 or 2). Content validity, assessed through the total CVI, was 0.90 out of 1.00, with the 17 ratings (16 items and the questionnaire as a whole) ranging from 0.66 to 1.00.

Testing of the Brazilian Portuguese Version

The Brazilian Portuguese version of the questionnaire was applied to 66 undergraduate students, 41 men (mean ± SD, age 21 ± 3 yr, weight 75 ± 12 kg, height 175 ± 6 cm, BMI 25 ± 4 kg/m²) and 25 women (mean ± SD, age 21 ± 1 yr, weight 60 ± 8 kg, height 166 ± 6 cm, BMI 22 ± 2 kg/m²) aged between 18-27 years. Of them, 4.6% (*n* = 3) reported no regular physical activity (0 sessions per week), whereas the others reported an average of 4.4 ± 1.7 sessions per week (*n* = 63), lasting for 74 ± 40 min and performed at an intensity of 4.9 ± 2 (*n* = 62) out of 10.0 on the adapted version of Borg`s Category Ratio 10 scale[26]. On average, they had been physically active for almost 4 years (42.5 ± 49.9 months, *n* = 58).

The degree of understanding of the questionnaire instructions was rated 4.97 (*n* = 36) (on a scale from 0.00 to 5.00). The degree of understanding of the 16 items ranged from 4.24 to 4.97 (*n* = 66). There were no refusals (response rate of 100%). Average response time (*n* = 33) was less than 3:30 min (204 ± 62 s).

Cronbach's alpha coefficient of internal consistency for the Preference and Tolerance scales was 0.91 and 0.82, respectively. The analysis of items revealed that, except for the tolerance question number 7, no item had a negative contribution to internal consistency. Deleting question number 7 slightly increases Cronbach's alpha coefficient from 0.82 to 0.85 for the Tolerance scale. All individual questions showed acceptably high correlations with the scores of their respective scales, except for question 7 from the Tolerance scale (Table 1). The test-retest reliability, which was examined after a 2-week interval, was 0.90 (95% CI = 0.84 - 0.93) for the Preference and 0.89 (95% CI = 0.82 - 0.93) for the Tolerance scale (Table 1). The 2-week test-retest reliability for each individual item is also presented in Table 1.

Self-reported intensity and frequency of habitual physical activity were significantly correlated with both the Preference and Tolerance scales. Session duration and the duration of lifetime involvement in habitual physical activity were significantly correlated only with the Tolerance scale. Regarding the Godin questionnaire scores, both Preference and Tolerance were significantly correlated with the total Leisure Activity Score. The same occurred for the frequency of strenuous exercise. Conversely, the frequency of moderate and mild exercise was not correlated with either Preference or Tolerance. Correlations and associated P values are shown in Table 2.

Table 1. Corrected item-total correlations and 2-week test-retest reliability

Preference Items		Q2	Q4	Q6	Q8	Q10	Q12	Q14	Q16	Preference total score
Corrected Item-Total Correlation With Preference Score	*r*	0.76	0.66	0.65	0.80	0.75	0.68	0.69	0.68	---
Test-Retest Reliability		0.85	0.72	0.65	0.75	0.63	0.49	0.53	0.73	0.90
Tolerance Items		**Q1**	**Q3**	**Q5**	**Q7**	**Q9**	**Q11**	**Q13**	**Q15**	**Tolerance total score**
Corrected Item-Total Correlation With Tolerance Score	*r*	0.55	0.59	0.64	0.14*	0.63	0.61	0.66	0.52	---
Test-Retest Reliability		0.60	0.79	0.65	0.54	0.71	0.70	0.77	0.57	0.89

All p values <0.01; *p>0.05

Table 2. Correlations between Preference and Tolerance scores with characteristics of habitual physical activity and GODIN Questionnaire scores

Characteristics of habitual physical activity	Preference		Tolerance	
	r	*P*	*r*	*P*
Intensity	0.48	< 0.01	0.57	< 0.01
Frequency	0.40	< 0.01	0.51	< 0.01
Session Duration	0.19	0.39	0.28	< 0.01
Duration of Life-time Involvement	0.16	0.71	0.24	< 0.01
Godin Questionnaire Scores	**Preference**		**Tolerance**	
	r	*P*	*r*	*P*
Total	0.20	0.03	0.40	< 0.01
Strenuous	0.29	< 0.01	0.49	< 0.01
Moderate	-0.02	0.87	0.13	0.16
Mild	0.04	0.69	-0.01	0.91

A total of 101 participants who had complete Preference and Tolerance data and indicated the highest prevalence of participation in strenuous, moderate, or mild exercise were identified. The Preference and Tolerance scores of the 24 participants who reported mostly strenuous, the 41 who reported mostly moderate, and the 36 who reported mostly mild exercise were compared. ANOVA was significant only for Preference ($F = 4.51$, $P = 0.013$, $\eta^2 = 0.08$). Post hoc comparisons showed that participants who performed strenuous exercise had significantly higher Preference scores (28.46) than those who performed moderate (24.76) or mild (24.86) exercise (Figure 2A). In contrast, the comparison between the Tolerance scores of those who performed strenuous (28.58), moderate (28.10), and mild (25.67) exercise did not reach significance ($F = 2.14$, $P = 0.12$, $\eta^2 = 0.04$). Additionally, those who reported working out long enough to work up a sweat "often" had higher Preference (27.47) and Tolerance (30.50) scores than those reporting "sometimes" (24.03 and 24.56, respectively) or "never/rarely" (22.17 and 23.09, respectively). ANOVA was significant for both Preference ($F = 11.11$, $P < 0.01$, $\eta^2 = 0.16$) and Tolerance ($F = 21.72$, $P < 0.01$, $\eta^2 = 0.27$). Post hoc comparisons showed that participants who reported “often” had significantly higher Preference and Tolerance scores than those reporting “sometimes” or “rarely/never” (Figure 2B).

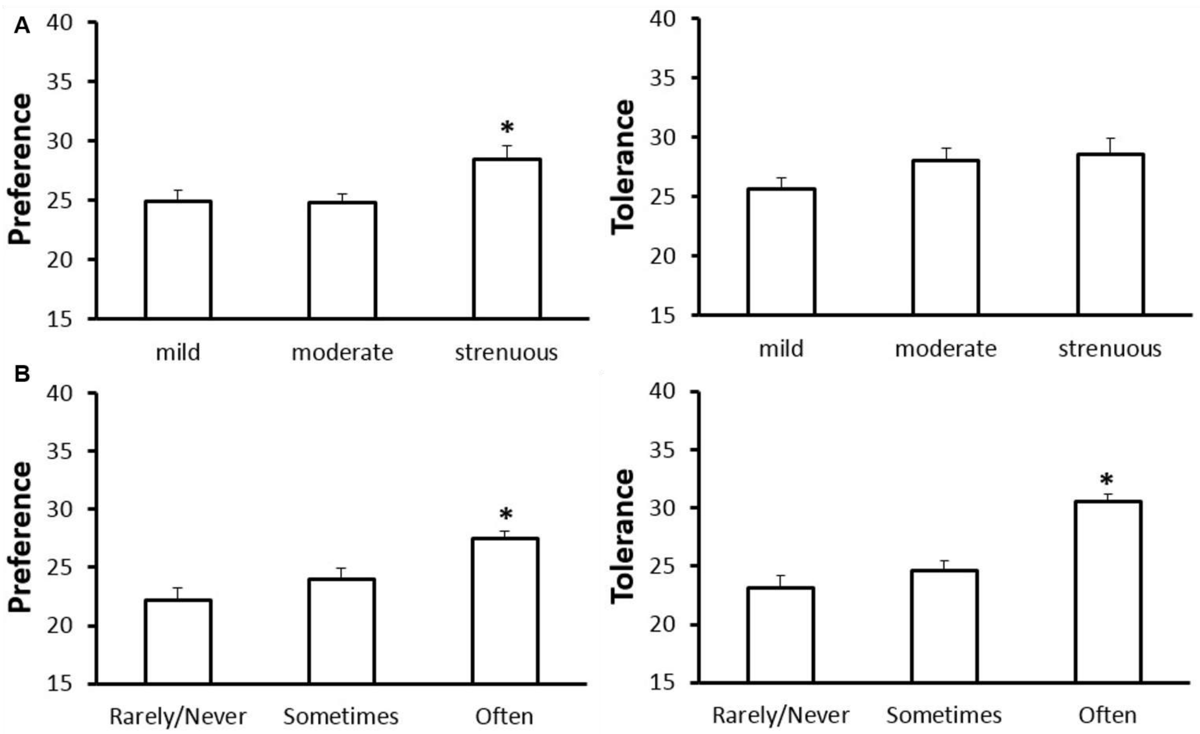

Figure 2. Differences (± standard error) in Preference (left) and Tolerance (right) scores among participants who reported a higher prevalence of participation in mild, moderate or strenuous exercise (**A**) and among participants who reported engaging in any regular activity long enough to work up a sweat (heart beats rapidly) “rarely/never”, “sometimes”, and “often” during a typical 7-day period (**B**). *Significant difference compared to mild and moderate (**A**) and compared to “rarely/never” and “sometimes” (**B**) ($P < 0.01$).

5.1.4. Discussion

The American College of Sports Medicine[21], one of the most important scientific and professional organizations in exercise science in the world, has recommended that individual differences in preference for and tolerance of exercise intensity should be considered in developing exercise prescriptions. Thus, the aim of the present study was to adapt the PRETIE-Q, a measure of these individual difference variables, for use in the Brazilian population. This effort is timely, since Brazil is heavily investing in policies to promote physical activity, especially through community exercise classes[22].

The translators, the back translator, the lead author of the original questionnaire, and the expert committee had only minor disagreements on the wording leading to the Brazilian Portuguese version of the PRETIE-Q. Semantic, idiomatic, cultural, and conceptual equivalences[23] were all well rated, with no item requiring revision. Similar results were found for content validity, evaluated by the CVI (rated 0.90 out of 1.00). Psychometric evaluation revealed that both the internal consistency and the test-retest reliability coefficients of the Brazilian Portuguese version were similar to or higher than those of the original questionnaire for both Preference and Tolerance scales[16–18]. Although the analysis of item revealed that question 7 (Tolerance scale) had a negative contribution to internal consistency, its removal would only slightly increase the alpha coefficient of internal consistency from 0.82 to 0.85. Thus, based on the appropriate equivalences and content validity ratings, it was decided not to exclude this item. Further investigations should explore the psychometric properties of this item in different populations. Analysis of the degree of understanding, response rate, and response time demonstrated that the Brazilian Portuguese version of PRETIE-Q is an easy, comprehensible, and practical instrument for the population studied (i.e., undergraduate students).

The initial evaluation of the construct validity of the Brazilian Portuguese version of the PRETIE-Q demonstrated that both Preference and Tolerance scales were correlated with the intensity and frequency of habitual physical activity (Table 2). In addition, the Tolerance scale was correlated with session duration and the duration of lifetime involvement in physical activity. Ekkekakis et al. have also found a correlation between Preference scale and self-reported intensity[16]. Similar to results obtained with the original PRETIE-Q[17], it was found that both Preference and Tolerance scales were correlated with the frequency of strenuous exercise and the Godin Leisure-Time Exercise Questionnaire scores, while no correlation was found with the frequency of moderate and mild exercise for the Preference scale (Table 2). Also consistent with the original PRETIE-Q[17], the present study found associations between Preference and Tolerance scales and physical activity participation in the vigorous or strenuous domains (Table 2 and Figure 2).

Further psychometric evaluations of the Brazilian Portuguese version of PRETIE-Q are necessary to address some of the study limitations. The sample of the present study consisted of undergraduate students (mainly Physical Education students). It is unknown whether a sample with different characteristics (age, educational level, fitness level, physical activity habits, etc.) would yield similar results. Also, in addition to the construct validity tests already performed[16–20], further investigations are required to expand the scope of psychometric analyses of both Brazilian Portuguese and English versions of the PRETIE-Q. Some of the strengths of the present study are the compliance with internationally established guidelines during the process of cultural adaptation[23,24], as well as the performance of initial psychometric evaluations consistent with the work on the original questionnaire[16,17], thus providing the opportunity for comparisons between the two versions.

Current guidelines for prescribing exercise intensity are based on a “recommended range” model. This “recommended range” is intentionally broad to accommodate individual differences in preference and tolerance, and to allow exercise professionals sufficient flexibility in designing and customizing exercise interventions for individuals and groups of clients or patients. However, it is clear that this broad range includes intensities that may be “too boring” for some participants and “too exhausting” for others[8]. When intensity is defined by an exercise professional, even small deviations from what an individual would have preferred could make the exercise feel less pleasant[29]. Mounting evidence indicates that the degree of pleasure or displeasure that participants experience during exercise[10] and the degree of enjoyment they report after exercise[30] predict subsequent physical activity. This evidence has led the American College of Sports Medicine[13] to conclude that “exercise that is pleasant and enjoyable can improve adoption and adherence to prescribed exercise programs” (p. 1334) and to recommend the use of a measure of individual differences for preference for and tolerance of exercise intensity[21], to "help identify what level of physical activity is appropriate to prescribe for different individuals" (p. 357). The cultural adaptation of the Brazilian Portuguese version of PRETIE-Q presented in this study, and additional psychometric studies with diverse samples to be completed in the future, will allow exercise professionals, including personal trainers, clinical exercise physiologists, and rehabilitation specialists, to incorporate assessments of individual differences in intensity preference and tolerance in their daily practice. Taking these individual differences into account in designing exercise prescriptions, as recommended in current guidelines[21], may facilitate the initial adoption of exercise and improve long-term adherence in programs such as “Academia da Saúde”.

For example, the American College of Sports Medicine[13] specifies that the range of “moderate” intensity, which is commonly recommended for beginners, extends from 64% to 76% of maximal heart rate. An exercise professional working at “Academia da Saúde” may select participants scoring above and below the median in preference and/or tolerance in the PRETIE-Q and administer two different exercise programs, one with intensity closer to 64-70% and the other with intensity closer to 70-76% of maximal heart rate. Tailoring the prescription according to preference and tolerance should increase the probability that the participants would be exercising closer to the intensity yielding optimal affective responses, thereby increasing the possibility of adherence[10]. It is important to emphasize, however, that additional research is needed for such customization algorithms to be fully developed and validated.

Brazilian researchers and practitioners now have the opportunity to further study the promising constructs of preference for and tolerance of the exercise intensity and to extend the process of psychometric testing beyond young adults. This study may also serve as a template for future adaptations of the PRETIE-Q in different languages. Next steps may include the exploration of specific participant characteristics (e.g., age and gender differences, differences between body mass index categories, or differences between groups with different health problems) and further determining the impact of preference for and tolerance of exercise intensity on exercise responses (e.g., affective responses, ratings of perceived exertion, and long-term exercise adherence).

5.1.5. Conclusion

The cultural adaptation and initial psychometric evaluation of the Brazilian Portuguese version of PRETIE-Q showed that the questionnaire retained its essential psychometric properties. Specifically, the Brazilian Portuguese version of PRETIE-Q (Appendix) demonstrated adequate internal consistency, good test-retest reliability, and meaningful cross-sectional correlations with several physical activity variables in a sample of young adults.

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5.1.7. Appendix (Article 1)

APPENDIX (Article 1)

Questionário de Preferência da Intensidade e Tolerância ao Exercício

Inventário de hábitos de exercício

Por favor, leia cada uma das afirmações seguintes e então utilize a escala de respostas abaixo para indicar se você concorda ou discorda delas. Não há respostas certas ou erradas. Responda rapidamente e assinale a resposta que melhor descreve o que você acredita e como você se sente. Certifique-se de responder todas as questões.

1 = Discordo totalmente   2 = Discordo   3 = Nem concordo nem discordo   4 = Concordo   5 = Concordo totalmente

1. Sentir-me cansado durante um exercício é meu sinal para diminuir ou parar.	1	2	3	4	5
2. Eu prefiro me exercitar em baixos níveis de intensidade por uma longa duração do que em altos níveis de intensidade por uma curta duração.	1	2	3	4	5
3. Durante o exercício, se meus músculos começam a queimar excessivamente ou se eu percebo que estou respirando com muito esforço, é hora de diminuir.	1	2	3	4	5
4. Eu prefiro ir devagar durante meu exercício, mesmo que isso signifique levar mais tempo.	1	2	3	4	5
5. Durante o exercício, eu tento continuar mesmo depois de me sentir exausto(a).	1	2	3	4	5
6. Eu prefiro realizar um exercício curto e intenso, do que um exercício longo e de baixa intensidade.	1	2	3	4	5
7. Eu bloqueio a sensação de fadiga quando me exercito.	1	2	3	4	5
8. Quando me exercito, eu geralmente prefiro um ritmo lento e constante.	1	2	3	4	5
9. Eu prefiro diminuir ou parar quando um exercício começa a ficar muito difícil.	1	2	3	4	5
10. Exercitar-me em baixa intensidade não me agrada nem um pouco.	1	2	3	4	5
11. Fadiga é a última coisa que me influencia a parar um exercício; eu tenho uma meta e paro somente quando a alcanço.	1	2	3	4	5
12. Quando me exercito, eu prefiro atividades que são de ritmo lento e que não requerem muito esforço.	1	2	3	4	5
13. Quando meus músculos começam a queimar durante um exercício, eu geralmente diminuo o ritmo.	1	2	3	4	5
14. Quanto mais rápido e difícil for o exercício, mais prazer eu sinto.	1	2	3	4	5
15. Eu sempre continuo a me exercitar, apesar da dor muscular e fadiga.	1	2	3	4	5
16. Exercício de baixa intensidade é entediante.	1	2	3	4	5

5.2. Article 2 – Preference for and Tolerance of the Intensity of Exercise Questionnaire: structural validity and multigroup factor invariance in a population sample

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TITLE

Preference for and Tolerance of the Intensity of Exercise Questionnaire: Structural validity and multigroup factor invariance in a population sample

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ABSTRACT

The purpose of this article was to test the structural validity and multigroup factor invariance of the Preference for and Tolerance of the Intensity of Exercise Questionnaire (PRETIE-Q) in a population sample. A cross-sectional study with 693 participants using in-home face-to-face interviews was conducted to assess demographic, anthropometric, leisure-time physical activity, and the PRETIE-Q information. Confirmatory factor analysis and multigroup factor invariance test across gender and age subgroups were performed. The two-factor model yielded a reasonably good fit for the sample, and reasonably good invariance across gender and age subgroups. Internal consistency ranged from 0.79 to 0.94 for the Preference and Tolerance scales across subgroups. The Preference and Tolerance scales of the PRETIE-Q were shown to be structurally valid and invariant across gender and age subgroups within a diverse population sample. These results add to the growing evidence base supporting the validity of the questionnaire and encourage its continued testing.

Key words: American College of Sports Medicine; adherence; physical activity; confirmatory factor analysis; psychometrics

5.2.1. Introduction

Exercise is medicine [1], as long as individuals are willing to engage in this behavior on a regular basis throughout their lives. This, however, has not been the prevalent scenario. Instead, physical inactivity is considered one of the greatest public health problems of the 21st century [2]. Among several constructs featured in behavioral theories of exercise, affective responses during exercise have recently emerged as one of the most promising, exhibiting reliable associations with subsequent physical activity behavior [3–5].

The way that exercise is experienced can vary widely between individuals. Some find even mild forms of exercise aversive while others thrive on, and persistently pursue, exercise at near-maximal or even supramaximal intensities. This variability persists even when intensity is expressed as a percentage of individual aerobic capacity or factors such as age, gender, or exercise experience are taken into account [6]. Current prescription guidelines for exercise intensity are based on a "recommended range" model, intended to offer both participants and exercise professionals flexibility in designing prescriptions that can accommodate a wide spectrum of individual "preferences and goals" [7]. Although it is clear that tailoring exercise prescriptions to individuals should be the goal, extant guidelines still do not specify a formal process for accomplishing this tailoring. Nevertheless, explicitly acknowledging the need for tailoring, the American College of Sports Medicine (ACSM) the leading scientific and professional organization of exercise science in the world, has noted that "*measures of individual exercise preference and tolerance could be useful for helping identifying what level of physical activity is appropriate to prescribe for different individuals*" (p. 357). At present, the only available measure of individual differences in exercise intensity preference and tolerance is the Preference for and Tolerance of the Intensity of Exercise Questionnaire (PRETIE-Q; [8]). Both the Preference and Tolerance scales have been found to correlate positively with affective responses during exercise [8]. In turn, affective responses have been found to predict physical activity behavior [3–5]. It is, therefore, reasonable to suggest that the PRETIE-Q may be a useful tool in the process of tailoring exercise intensity prescriptions to individuals and/or groups. For instance, individuals with higher Tolerance scores have been found to report more positive affective responses compared to those with lower Tolerance scores during exercise performed at the same relative intensity [9].

The PRETIE-Q has demonstrated satisfactory internal consistency and test-retest reliability, as well as evidence of construct validity among both English- and Brazilian Portuguese-speaking respondents [8,10,11]. For instance, the Preference and Tolerance scales were shown to predict self-selected exercise intensity [12] and the amount of time individuals persevered beyond the intensity corresponding to the ventilatory threshold [13], respectively. Despite prior use of the PRETIE-Q with middle-aged women [12] and elderly individuals [14] and the aforementioned recommendation by the ACSM, thus far the structural validity of the questionnaire has only been investigated in college-age adults [8,10]. Moreover, it is unknown whether the factor structure of the PRETIE-Q remains invariant across different population subgroups. This may compromise the applicability of the ACSM recommendations and limit the scope of utilization of the PRETIE-Q for both research and practice in the domain of public health. Thus, the purpose of the present study was to test the structural validity of the PRETIE-Q in a diverse population sample and to evaluate its factorial invariance across gender and age subgroups.

5.2.2. Methods

This cross-sectional population study was conducted in the city of Rio Claro, in southeastern Brazil, 180 kilometers from the capital of São Paulo. The city covers a land area of approximately 498 km^2, with a population density of 373 habitants/km^2, a total population of 186,253 people, and a Human Development Index of 0.803.

Procedures

In 2007-2008, a stratified random sampling procedure was used to select a representative sample of adults (20 years or older) living in the city of Rio Claro, resulting in a sample of 1588 individuals interviewed. Detailed information regarding data collection is provided in previously published articles from the 2007-2008 study [15–17].

The present study, which was conducted in 2014-2015, was the follow-up stage of the aforementioned study. Thus, it was a cross-sectional study involving a population sample of adults (≥ 26 years old). From the original 1588 participants in 2007-2008, 693 were contacted and successfully interviewed in 2014-2015. Briefly, participants lost to follow-up included those who changed address and could not be found (n = 342), those who refused to participate (n = 144), those who had died (n =

81), among other reasons. Face-to-face interviews were conducted at the participants' homes, using an electronic questionnaire format on tablets running the *Open Data Kit* (ODK) app. All participants signed a consent form prior to participation, which had been approved by the local Ethics Committee (No. 430.908) according to the standards set by Resolution 466/12.

Questionnaires

A survey including basic demographic and self-reported anthropometric information such as age, socioeconomic status, educational level, weight, and height was administered. Age categories were: young adults (26-39 years); middle-age adults (40-59 years); and older adults (≥ 60 years). Weight and height were used to calculate the body mass index (BMI), which was categorized as: normal-weight (≤ 24.99 $kg{\cdot}m^{-1}$); overweight (25.00-29.99 $kg{\cdot}m^{-1}$); or obese (≥ 30.00 $kg{\cdot}m^{-1}$). Socioeconomic status was assessed by the purchasing power as estimated by the Brazilian Market Research Association (BMRA) questionnaire. Educational level was assessed by the question "What was your final year of study?". Response options were: (i) none or up to 4th grade incomplete; (b) up to 4th grade complete or primary school incomplete; (c) primary school complete or secondary education incomplete; (d) secondary education complete or high school incomplete; or (e) high school complete.

Leisure-time physical activity (PA) of moderate and vigorous intensity was assessed by the International Physical Activity Questionnaire (IPAQ) - long version, translated and validated for the Brazilian population [18]. Questions assessing both moderate- and vigorous-intensity PA referred to the week prior to the interview, with a minimum duration of at least 10 minutes per session. Total leisure-time PA was calculated as (duration of vigorous PA x 2) + (duration of moderate PA x 1). Leisure-time PA was categorized as: inactive (≤ 9 min/week); insufficiently active (10-149 min/week); active (150-299 min/week); very active (≥ 300 min/week).

The Preference for and Tolerance of the Intensity of Exercise Questionnaire (PRETIE-Q) was also administered [8]. The PRETIE-Q consists of two 8-item scales, namely Preference and Tolerance, with each item accompanied by a 5-point response scale. The Preference scale contains four items that measure preference for high-intensity (Items 6, 10, 14, 16) and four that measure preference for low-intensity exercise (Items 2, 4, 8, 12). Similarly, the Tolerance scale contains four items that measure high tolerance (Items 5, 7, 11, 15) and four that measure low tolerance of high exercise intensity (Items 1, 3, 9, 13). Items indicative of preference for low intensity (Items 2, 4, 8, 12) and items indicative of low tolerance (Items 1, 3, 9, 13) are reversed-scored. Thus, the possible score range for each scale is 8-40. For the present study, the Brazilian Portuguese adaptation of the PRETIE-Q was used [11]. Unlike previous studies in which the questionnaire was self-adminitered, in this case the PRETIE-Q was administered in interview format. Pilot testing demonstrated difficulty in answering the original 5-point response scale in the interview format. Thus, all items were presented in question format (rather than as affirmative statements) and in the second person (rather than in the first person). Also, to facilitate the interview administration, the response scale was altered from "*I totally disagree/I disagree/I neither agree nor disagree/I agree/I totally agree*" to "*No, never/No, almost never/Sometimes/Yes, almost always/Yes, always*".

Data Analysis

<u>Confirmatory factor analysis</u>

A confirmatory factor analysis was conducted using Amos 22.0.0 [19] with the maximum likelihood method of estimation, following the recommendations of Byrne [20]. The model followed the specifications of two prior confirmatory factor analyses [8,10]. Thus, we used a correlated two-factor model consisting of one eight-item Preference factor and one eight-item Tolerance factor, as well as four correlated errors between Preference items 2-6, 4-8, 10-16 and Tolerance items 3-13 [8,10]. Both the univariate and multivariate distribution of observed variables were tested for normality, according to the recommendations of Byrne [20]. Since there was evidence of multivariate kurtosis (Mardia's coefficient = 158.13), we also analyzed the same data using the Satorra-Bentler robust approach as implemented in EQS 6.1 [21]. To allow comparisons, we used similar goodness-of-fit indices as those used in previous studies [8,10]. Thus, we present both chi-square (χ^2) and Satorra-Bentler scaled chi-square (SB χ^2), goodness-of-fit index (GFI), comparative fit index (CFI), EQS "robust" comparative fit index (CFI*), and root mean square error of approximation (RMSEA) with associated 90% confidence intervals.

<u>Multigroup invariance</u>

Multigroup invariance was tested first for gender (women vs. men) and then for age (< 55 years vs. ≥55 years). These age subgroups were formed in order to avoid unequal sample sizes that could affect the goodness of fit indices [22]. All procedures followed the steps recommended by Byrne [20]. Briefly, the test of multigroup invariance involved a series of increasingly stringent steps: (i) establishing goodness-of-fit for the configural model; (ii) testing for the invariance of the factor loadings (measurement model); and (iii) testing for the invariance of the factor covariances (structural model). In interpreting measurement and structural invariance, a change of ≥ -0.010 in CFI supplemented by a change of ≥ 0.015 in RMSEA or a change of ≥ 0.030 in standardized root mean square residual (SRMR) was used as an indication of noninvariance [22].

Internal Consistency and Corrected Item-Total Correlations

The internal consistency of both the Preference and Tolerance scales was assessed by Cronbach's alpha coefficient, while the Pearson correlation coefficient was used to assess corrected item-total correlations.

5.2.3. Results

Sample Characteristics

From the total sample of 693 participants, 622 participants who completed the PRETIE-Q in full (i.e., responded to all items) were included in subsequent analyses. Table 1 summarizes the characteristics of the sample. Briefly, the sample involved participants ranging from 26 to 95 years of age, mainly women (60.6%), middle-aged (43.7%), with high socioeconomic status (54.3%), > 8 years of education (48.1%), normal BMI (38.0%), and ≤ 9 min/week of leisure-time physical activity (54.2%).

Table 1 - Sample characteristics (n = 622)

Variable	Total n (%)	Women n (%)	Men n (%)
Gender			
Women	377 (60.6)	-	-
Men	245 (39.4)	-	-
Age group			
Adults	121 (19.5)	71 (18.8)	50 (20.4)
Middle-age	272 (43.7)	167 (44.3)	105 (42.9)
Elderly	229 (36.8)	139 (36.9)	90 (36.7)

Socioeconomic status*			
High	330 (54.3)	193 (52.7)	137 (56.6)
Medium	254 (41.8)	154 (42.1)	100 (41.3)
Low	24 (3.9)	19 (5.2)	5 (2.1)
Educational level (years)			
< 4	231 (37.1)	152 (40.3)	79 (32.2)
4 - 8	92 (14.8)	49 (13.0)	43 (17.6)
> 8	299 (48.1)	176 (46.7)	123 (50.2)
BMI group†			
Normal	234 (38.0)	141 (38.1)	93 (38.0)
Overweight	221 (35.9)	135 (36.5)	86 (35.1)
Obese	160 (26.0)	94 (25.4)	66 (26.9)
Hypertension	245 (39.4)	164 (43.5)	81 (33.1)
Diabetes††	102 (16.5)	68 (18.1)	34 (13.9)
Leisure-time PA (min/week)			
≤ 9	337 (54.2)	218 (57.8)	119 (48.6)
10 - 149	104 (16.7)	68 (18.0)	36 (14.7)
150 - 299	73 (11.7)	37 (9.8)	36 (14.7)
≥ 300	108 (17.4)	54 (14.3)	54 (22.0)

* n = 608; † n = 615; †† n = 620

Confirmatory Factor Analysis

As shown in Table 2, the confirmatory factor analysis ("Full-sample Model") yielded a reasonably good fit, especially after the Satorra-Bentler correction. To facilitate comparisons, Table 2 also presents the results of the two previously published covariance structure models for the PRETIE-Q involving US college-age adults [8,10]. The present results demonstrate that the PRETIE-Q covariance structure remained similar, or better, in our population sample compared to samples of young adults. The results of our confirmatory factor analysis are also represented graphically in Figure 1. In general, standardized factor loadings were acceptably high for both the Preference (0.73 to 0.83) and Tolerance (0.45 to 0.76) latent factors, except for item 11 (Tolerance scale), which yielded a factor loading of 0.28. The correlation between the latent factors of Preference and Tolerance was 0.60.

Table 2. Degrees of freedom (d.f.), chi-square (χ^2), goodness-of-fit index (GFI), comparative fit index (CFI), and root mean square error of approximation (RMSEA) with associated 90% confidence intervals (when available) for the three covariance structure models compared.

Model Comparisons	d.f.	χ^2	GFI	CFI	RMSEA
Full-sample Model (present study)	99	478.9 311.7*	0.90	0.93 0.95*	0.08 (0.07 - 0.09) 0.06 (0.05 - 0.07)*
Male and Female Students (Ekkekakis et al, 2005)	99	128	0.92	0.97	0.04
College Women (Ekkekakis et al, 2008)	99	492.7 403.2*	0.89	0.91 0.91*	0.08 (0.07 - 0.09)

* EQS “robust” indexes from Satorra-Bentler correction.

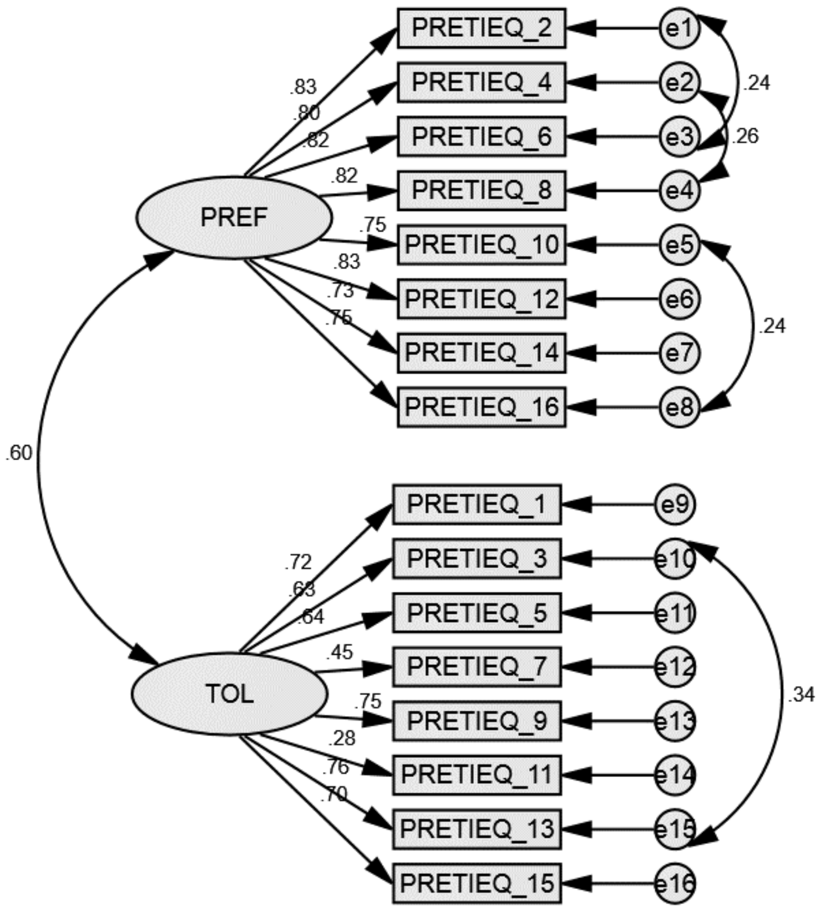

Figure 1. Results of the confirmatory factor analysis of the PRETIE-Q in a population-based sample. The numbers represent standardised coefficients.

Multigroup Invariance

Goodness-of-fit statistics for the baseline models of each gender group are shown in Table 3. Baseline models for women and men demonstrated similar results. After establishing the configural model, comparisons with the measurement and structural models (Table 3) demonstrated reasonably good invariance across genders (ΔCFI = 0.001; ΔRMSEA = -0.003; ΔSRMR = 0.0010 to 0.0019).

Table 3 - A) Goodness-of-fit statistics in determining of baseline model; B) Goodness-of-fit statistics for test of multigroup invariance between gender groups.

A - Baseline Model	df	χ^2	GFI	CFI	RMSEA
Women (n = 377)	99	337.8	0.89	0.92	0.08 (0.07 - 0.09)
Men (n = 245)	99	303.2	0.85	0.92	0.09 (0.08 - 0.10)

B - Multigroup Invariance	Comparative model	χ^2	df	CFI	ΔCFI	RMSEA	ΔRMSEA	SRMR	ΔSRMR
1. Configural model (no equality constraints imposed)	---	641.0	198	0.922	---	0.060 (0.055 - 0.065)	---	0.0577	---
2. Measurement model (all factor loadings constrained equal)	2 versus 1	654.1	216	0.923	0.001	0.057 (0.052 - 0.062)	-0.003	0.0587	0.001
3. Structural model (model 2 with covariances between PREF and TOL constrained equal)	3 versus 1	655.8	217	0.923	0.001	0.057 (0.052 - 0.062)	-0.003	0.0596	0.0019

χ2 - chi-square; GFI - goodness-of-fit index; CFI – comparative fit index; RMSEA - root mean square error of approximation; SRMR - standardized root mean square residual.

Regarding the age subgroups, goodness-of-fit statistics for the baseline model are presented in Table 4. The baseline model for the older group (≥ 55 years) demonstrated slightly worse fit. Nonetheless, comparisons for the measurement and structural models in relation to the configural model (Table 4) demonstrated that both factor loadings and factor covariances were invariant between age subgroups (ΔCFI = -0.009 to -0.010; ΔRMSEA = 0.000; ΔSRMR = 0.0008 to 0.0088).

Table 4 - A) Goodness-of-fit statistics in determining of baseline model; B) Goodness-of-fit statistics for test of multigroup invariance between age groups.

A - Baseline Model	df	χ^2	GFI	CFI	RMSEA
< 55 (n = 320)	99	301.6	0.88	0.93	0.08 (0.07 - 0.09)
≥ 55 (n = 302)	99	399.6	0.84	0.87	0.10 (0.09 - 0.11)

B - Multigroup Invariance	Comparative model	χ^2	df	CFI	ΔCFI	RMSEA	ΔRMSEA	SRMR	ΔSRMR
1. Configural model (no equality constraints imposed)	---	701.2	198	0.904	---	0.064 (0.059 - 0.069)	---	0.0559	---
2. Measurement model (all factor loadings constrained equal)	2 versus 1	765.4	216	0.895	-0.009	0.064 (0.059 - 0.069)	0,000	0.0567	0.0008
3. Structural model (model 2 with covariances between PREF and TOL constrained equal)	3 versus 1	769.3	217	0.894	-0.010	0.064 (0.059 - 0.069)	0,000	0.0647	0.0088

χ2 - chi-square; GFI - goodness-of-fit index; CFI – comparative fit index; RMSEA - root mean square error of approximation; SRMR - standardized root mean square residual.

Internal Consistency and Corrected Item-Total Correlations

Cronbach's alpha coefficient of internal consistency for the Preference and Tolerance scales varied across gender and age subgroups from 0.87 to 0.94 and from 0.79 to 0.81, respectively (Table 5). The item analysis revealed that, except for Tolerance item number 11, no item had a negative contribution to internal consistency. Deleting item number 11 would slightly increase Cronbach's alpha for the Tolerance scale for all gender and age subgroups (with the largest change for men < 55 years, from 0.81 to 0.84). All items showed acceptably high correlations with the scores of their respective scales across all gender and age subgroups (from 0.39 to 0.84), except for item number 11 from the Tolerance scale (see Table 6).

Table 5. Internal consistency for the Preference and Tolerance scales across all 4 subgroups.

	Preference	Tolerance
Women < 55 (n = 196)	0.93	0.81
Women ≥ 55 (n = 181)	0.87	0.79
Men < 55 (n = 124)	0.94	0.81
Men ≥ 55 (n = 121)	0.92	0.81

Table 6. Corrected item-total correlations for the Preference and Tolerance scales across all 4 subgroups

Preference Questions		Q2	Q4	Q6	Q8	Q10	Q12	Q14	Q16
Women < 55 (n = 196)	*r*	0.79	0.74	0.76	0.84	0.74	0.77	0.67	0.73
Women ≥ 55 (n = 181)	*r*	0.61	0.64	0.67	0.59	0.63	0.72	0.57	0.61
Men < 55 (n = 124)	*r*	0.82	0.81	0.84	0.79	0.76	0.77	0.77	0.78
Men ≥ 55 (n = 121)	*r*	0.78	0.79	0.76	0.75	0.68	0.73	0.64	0.74
Tolerance Questions		**Q1**	**Q3**	**Q5**	**Q7**	**Q9**	**Q11**	**Q13**	**Q15**
Women < 55 (n = 196)	*r*	0.64	0.52	0.61	0.39	0.59	0.29	0.63	0.63
Women ≥ 55 (n = 181)	*r*	0.54	0.56	0.53	0.49	0.61	0.36	0.57	0.62
Men < 55 (n = 124)	*r*	0.58	0.44	0.61	0.49	0.64	0.18	0.65	0.66
Men ≥ 55 (n = 121)	*r*	0.64	0.55	0.57	0.49	0.53	0.38	0.61	0.63

5.2.4. Discussion

The present results, involving a diverse sample in terms of age, socioeconomic and educational levels, BMI, health status and leisure-time physical activity, demonstrated that the PRETIE-Q is structurally valid and that its structure remains invariant across gender and age subgroups. The confirmatory factor analysis in our entire population sample (Table 2) yielded satisfactory indices of model fit, similar (or better) compared to previous studies with college-age participants from the US [8,10]. With the sole exception of item 11 (from the Tolerance scale), standardized factor loadings were adequate. Moreover, all four correlated errors between items, as well as the correlation between the latent factors of Preference and Tolerance were similar to those in the original structural validation studies [8,10]. In addition, the tests of multigroup invariance demonstrated that the PRETIE-Q maintains its factorial structure across gender (Table 3) and age (Table 4) subgroups. Although the analysis for the age subgroups showed lower goodness-of-fit indices compared to the gender group comparisons, those indices remained above the "cutoff" values proposed as indications of noninvariance [22]. Lastly, both gender- and age-specific indices of internal consistency and corrected item-total correlations were acceptably high, except for item 11 from the Tolerance scale. Its removal, however, would increase internal consistency by no more than 0.03 (in the group of men < 55 years). Since internal consistency ranged from 0.79 to 0.94 across subgroups (Table 5), similarly to the original validation studies [8,10], the removal of item 11 is not deemed necessary on psychometric grounds.

It should be pointed out that this was the first time that the PRETIE-Q was administered in an interview format, as opposed to being self-administered. Our modification of the items into questions (rather than affirmative statements) and the changes to the response scale (see *Methods*) did not seem to negatively influence the results of the confirmatory factor analysis. Indeed, comparisons with previously published covariance structure models involving US college-age adults (Table 2) demonstrated similar, or better, results.

While the ongoing psychometric evaluation of the PRETIE-Q has produced promising results, considerable work remains to be done for the vision of an instrument that can be used in "*identifying what level of physical activity is appropriate to prescribe for different individuals*" [7], can be realized. Firstly, it is unclear which scale (Preference or Tolerance) would be more useful in what circumstances. Although both scales are associated with affective responses during exercise [8] and have been found to be intercorrelated in this (0.60) and previous studies (0.59 in [10] and 0.45 in [8]), they have also demonstrated discriminant validity and may be useful in different roles. For instance, preference for exercise intensity was defined as "*a predisposition to select a particular level of exercise intensity when given the opportunity (e.g., when engaging in self-selected or unsupervised exercise)*" [8]. Accordingly, the Preference scale of the PRETIE-Q has been found to account for 17-18% of the variance in self-selected exercise intensity beyond the variance accounted for by age, body mass index, and peak oxygen uptake [12]. Tolerance of exercise intensity was defined as "*a trait that influences one's ability to continue exercising at an imposed level of intensity even when the activity becomes uncomfortable or unpleasant*" [8]. Accordingly, the Tolerance scale has been found to account for 14-20% of the variance in the amount of time participants persevered beyond the ventilatory threshold beyond the variance accounted for by age, body mass index, and peak oxygen uptake [13]. Secondly, except for young college women [10]), there are no population-level normative values upon which to decide what represents low, medium, or high values. Taking an experimental approach to the problem, Tempest and Parfitt [9] showed that individuals with low tolerance scores (mean of 21.1) reported lower affective valence (1-2 points lower on an 11-point scale) than individuals with high tolerance scores (mean of 33.1) in response to exercise intensities above the ventilatory threshold, despite both groups having similar fitness levels. Such a difference may be relevant in practical terms, as a positive shift of 1 point in affective valence has been found to be associated, both concurrently and prospectively, with 15 to 41 minutes of additional physical activity per week [23,24]. Lastly, whether exercise behavior (e.g., adherence) can be improved by using the PRETIE-Q to tailor individual and/or group exercise prescriptions remains unexplored.

As both validation and applicability studies of the PRETIE-Q continue, an additional aspect of interest may be understanding which factors are associated with the constructs of Preference for and Tolerance of the intensity of exercise, such as age, gender, body mass index, chronic diseases, physical activity levels, and genetics. For instance, further research on the factors related to these individual-difference variables may help explaining the causes of the "*extreme avoidance of physical activity and exercise in obesity*" [25], as well as identify possible roles for genetics in modulating affective responses to exercise [26].

5.2.5. Conclusion

In conclusion, the Preference and Tolerance scales of the PRETIE-Q were shown to be structurally valid and invariant across gender and age subgroups in a diverse population sample. This investigation expands the evidence base supporting the validity of the PRETIE-Q in the general population. In this sense, this study further strengthens the empirical basis behind the recommendation to use the PRETIE-Q in the process of tailoring exercise prescriptions to individuals [7]. Moreover, the positive results reported here serve to encourage further investigations into the constructs of Preference and Tolerance.

ETHICAL APPROVAL: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

INFORMED CONSENT: Informed consent was obtained from all individual participants included in the study.

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5.3. Article 3 – Preference for and Tolerance of the Intensity of Exercise: factors associated and population-based normative values

This manuscript will be submitted to a scientific journal after all authors approve the final version.

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ABSTRACT

Purpose: to explore the factors associated with Preference for and Tolerance of the exercise intensity in a diverse population sample, as well as to provide population-based normative values. Methods: cross-sectional study involving 693 individuals. Face-to-face interviews were conducted at the participants' homes. Assessments included demographic and anthropometric characteristics, leisure-time physical activity (LTPA), and the Preference for and Tolerance of the Intensity of Exercise Questionnaire (PRETIE-Q). Multiple linear regression and partial correlations were performed to evaluate the associations of age, gender, BMI and moderate and vigorous LTPA with the Preference and Tolerance scores. Results: based on 622 individuals with complete data, the initial multiple linear regression revealed that age and BMI (inversely), and vigorous LTPA and gender (positively) were associated with the Preference scores, while age (inversely), and vigorous and moderate LTPA (positively) were associated with the Tolerance scores. Among these significant predictor variables, however, only age ($r = -0.348$ and $r = -0.341$) and vigorous LTPA ($r = 0.276$ and $r = 0.140$) were found to be significantly and independently associated with both Preference and Tolerance scores, respectively. In addition, population-based normative values stratified by age categories are presented. Conclusion: Preference for and Tolerance of the intensity of exercise scores are associated with age (inversely) and vigorous LTPA (positively) in a diverse population sample. Future studies are

encouraged to determine meaningful differences in Preference and Tolerances scores and their respective impact on affective responses and exercise behavior.

5.3.1. Introduction

Although the efficacy of exercise has been demonstrated for over 35 chronic conditions (Booth, Roberts, & Laye, 2012), its health-related effectiveness is severely threatened by the low levels of participation or adherence. Put simply, exercise is a “miracle drug” (Pimlott, 2010) only when individuals are willing to take it frequently. It is becoming evident that when exercise is felt as a “bitter pill” to take (i.e., aversive experience), individuals tend to avoid repeating such experience, that is, how someone feels during exercise can partially influence exercise behavior (Ekkekakis, Hargreaves, & Parfitt, 2013; Williams, 2008). In this context, affective responses during exercise has emerged as a promising variable to help understanding the complex puzzle of exercise behavior (Ekkekakis et al., 2013), with empirical findings of concurrent and prospective associations with exercise levels (Rhodes & Kates, 2015; Rhodes & Quinlan, 2015).

An important feature of affective responses during exercise has been its large interindividual variability, even when intensity is normalized for the fitness level of each individual or factors such as age, gender or exercise experience are taken into account (for a review see Ekkekakis, Parfitt, & Petruzzello, 2011). For instance, when physically active young adults ran on a treadmill for 15min at an intensity below of their individually established ventilatory threshold, 7% of participants showed increases, 50% showed no changes, and 43% showed decreases in affective responses

(Ekkekakis, Hall, & Petruzzello, 2008). In an invited guest editorial, Ekkekakis and colleagues (2013) have raised several lines of research with potential to shed light on this phenomenon, such as the influence of constructs of self-efficacy, motivational states, perceived autonomy, attentional focus, social environment, personality traits, among other individual-difference variables. The personality traits of preference for and tolerance of exercise intensity have been particularly encouraging, as they correlate with affective responses during exercise (Ekkekakis, Hall, & Petruzzello, 2005) and it has been found that, despite similar fitness level and for the same relative exercise intensity, individuals with higher tolerance report more positive affective responses when compared to those with lower tolerance (Tempest & Parfitt, 2016).

In acknowledging the problem of exercise adherence, the American College of Sports Medicine (ACSM, 2013) has noted that "“*measures of individual exercise preference and tolerance could be useful for helping identifying what level of physical activity is appropriate to prescribe for different individuals*” (p. 357). The rationale is that using such constructs to provide individual tailoring of exercise prescriptions may lead to an improved exercise experience (e.g., improved affective responses, enjoyment, etc), thereby improving adherence (Garber et al., 2011). For example, one contributing factor for the “*extreme avoidance of physical activity in obesity*” (Ekkekakis, Vazou, Bixby, & Georgiadis, 2016) is believed to be the more unpleasant (or less pleasant) feelings during exercise experienced by overweight and obese individuals when compared to their normal-weight counterparts, even at the same relative exercise intensity (Ekkekakis, Lind, & Vazou, 2010; Ekkekakis & Lind, 2006). One of the possible explanations is that these individuals may present lower levels of preference for and tolerance of the exercise intensity (Ekkekakis et al., 2016). Importantly, this may also be a contributing factor exactly to those population subgroups that present the worst scenario in terms of exercise participation/adherence, such as females, older adults, overweight and obese individuals, individuals with poor health status and low self-efficacy, among others (Bauman et al., 2012).

Preliminary evidence suggests that this may be the case, with scores of preference for and tolerance of the exercise intensity lower in middle-age women (Ekkekakis, Lind, & Joens-Matre, 2006) than in college-age women (Ekkekakis, Thome, Petruzzello, & Hall, 2008), lower in college women than in college men (Hall, Petruzzello, Ekkekakis, Miller, & Bixby, 2014; Lochbaum, Stevenson, & Hilario, 2009), scores inversely associated with body mass index (Hall et al., 2014), and positively associated with leisure-time physical activity levels (Ekkekakis, Thome, et al., 2008; Hall et al., 2014). To date, however, there has been no investigation of these constructs in a diverse population sample in terms of age, gender, body mass index, physical activity levels, etc. Thus, the purpose of this study is to explore the factors associated with preference for and tolerance of the exercise intensity in a diverse population sample, as well as to provide population-based normative values.

5.3.2. Methods

This cross-sectional population study was conducted in the city of Rio Claro, in southeastern Brazil, 180 kilometers from the capital of São Paulo. The city covers a land area of approximately 498 km^2, with a population density of 373 habitants/km^2, a total population of 186,253 people, and a Human Development Index of 0.803 (Atlas do Desenvolvimento Humano no Brasil, 2013).

Procedures

In 2007-2008, a stratified random sampling procedure was used to select a representative sample of adults (20 years or older) living in the city of Rio Claro, resulting in a sample of 1588 individuals interviewed. Detailed information regarding data collection is provided in previously published articles from the 2007-2008 study (Nakamura et al., 2014; Sebastião et al., 2012, 2013).

The present study, which was conducted in the years of 2014-2015, was the follow-up stage of the aforementioned study. Thus, it was a cross-sectional study involving a population sample of adults (≥ 26 years old). From the original 1588 participants in 2007-2008, 693 were contacted and successfully interviewed in 2014-2015. Briefly, participants lost to follow-up included those who changed address and could not be found (n = 342), those who refused to participate (n = 144), those who died (n = 81), among others. Face-to-face interviews were conducted at the participants' homes, using an electronic questionnaire format on tablets running the Open Data Kit (ODK) app. All participants signed a consent form prior to participation, which had been approved by the local Ethics Committee (No. 430.908) according to the standards set by Resolution 466/12.

Questionnaires

A survey including basic demographic and self-reported anthropometric information such as age, weight, and height was administered. Age categories were: adults (26-39 years); middle-age adults (40-59 years); and older adults (> 60 years). Weight and height were used to calculate the body mass index (BMI), which was categorized as: normal-weight (≤ 24.99 $kg{\cdot}m^{-1}$); overweight (25.00-29.99 $kg{\cdot}m^{-1}$); or obese (≥ 30.00 $kg{\cdot}m^{-1}$).

Leisure-time physical activity (PA) of moderate and vigorous intensity was assessed by the International Physical Activity Questionnaire (IPAQ) - long version, translated and validated for the Brazilian population (Matsudo et al., 2001). Questions assessing both moderate- and vigorous-intensity PA referred to the week prior to the interview, with a minimum duration of at least 10 minutes per session. Moderate (< 10min; ≥ 10min < 150min; ≥ 150min) and vigorous (< 10min; ≥ 10min < 75min; ≥ 75min) LTPA were categorized according to global recommendations for health (WHO, 2010).

The Preference for and Tolerance of the Intensity of Exercise Questionnaire (PRETIE-Q) was also administered (Ekkekakis et al., 2005). The PRETIE-Q consists of two 8-item scales, namely Preference and Tolerance, in which each item is accompanied by a 5-point response scale. The Preference scale contains four items that measure preference for high-intensity (Items 6, 10, 14, 16) and four that measure preference for low-intensity exercise (Items 2, 4, 8, 12). Similarly, the Tolerance scale contains four items that measure high tolerance (Items 5, 7, 11, 15) and four that measure low tolerance of high exercise intensity (Items 1, 3, 9, 13). Items indicative of preference for low intensity (Items 2, 4, 8, 12) and items indicative of low tolerance (Items 1, 3, 9, 13) are reversed-scored. Thus, the possible score range for each scale is 8-40. For the present study, the Brazilian Portuguese adaptation of the PRETIE-Q was used (Smirmaul, Ekkekakis, Teixeira, Nakamura, & Kokubun, 2015), and its application followed the same procedures from our previous structural validity study (Article 2 of this PhD Thesis).

Data Analysis

Firstly, the Preference and Tolerance scores were compared according to their population subgroups (i.e., adults *vs* middle age *vs* older adults, men *vs* women, normal weight *vs* overweight *vs* obese, <10min *vs* ≥10<150min *vs* ≥150min of moderate LTPA levels, and <10min *vs* ≥10<75min *vs* ≥75min of vigorous LTPA levels), using 95% confidence intervals (CI). These population subgroups were chosen based on preliminary associations previously reported: i) age – lower scores in middle-age women (Ekkekakis et al., 2006) than in college-age women (Ekkekakis, Thome, et al., 2008); ii) gender – lower scores in college women than in college men (Hall et al., 2014; Lochbaum et al., 2009); iii) BMI – partial correlations (controlling for age) between body fat and Preference (≈ -0.31) and Tolerance (≈ -0.27) scores in both college women and men (Hall et al., 2014); iv) LTPA – associations between LTPA and Preference and Tolerance scores between 3-9% (Ekkekakis, Thome, et al., 2008; Hall et al., 2014). As all subgroups demonstrated at least one difference in the Preference and/or Tolerance scores when compared by the 95% CI, we then conducted a multiple linear regression to evaluate the associations of age, gender, BMI and moderate and vigorous LTPA with the Preference and Tolerance scores. Also, partial correlations were performed between the significant predictor variables and the Preference and Tolerance scores, in order to ensure independent associations. Significance was set at $p < 0.05$ for multiple linear regressions and at $p < 0.001$ for partial correlations, in order to control for the multiple comparisons problem.

5.3.3. Results

For all population subgroups, there was at least one difference in the Preference and/or Tolerance scores when compared by the 95% CI, as shown in Figure 1.

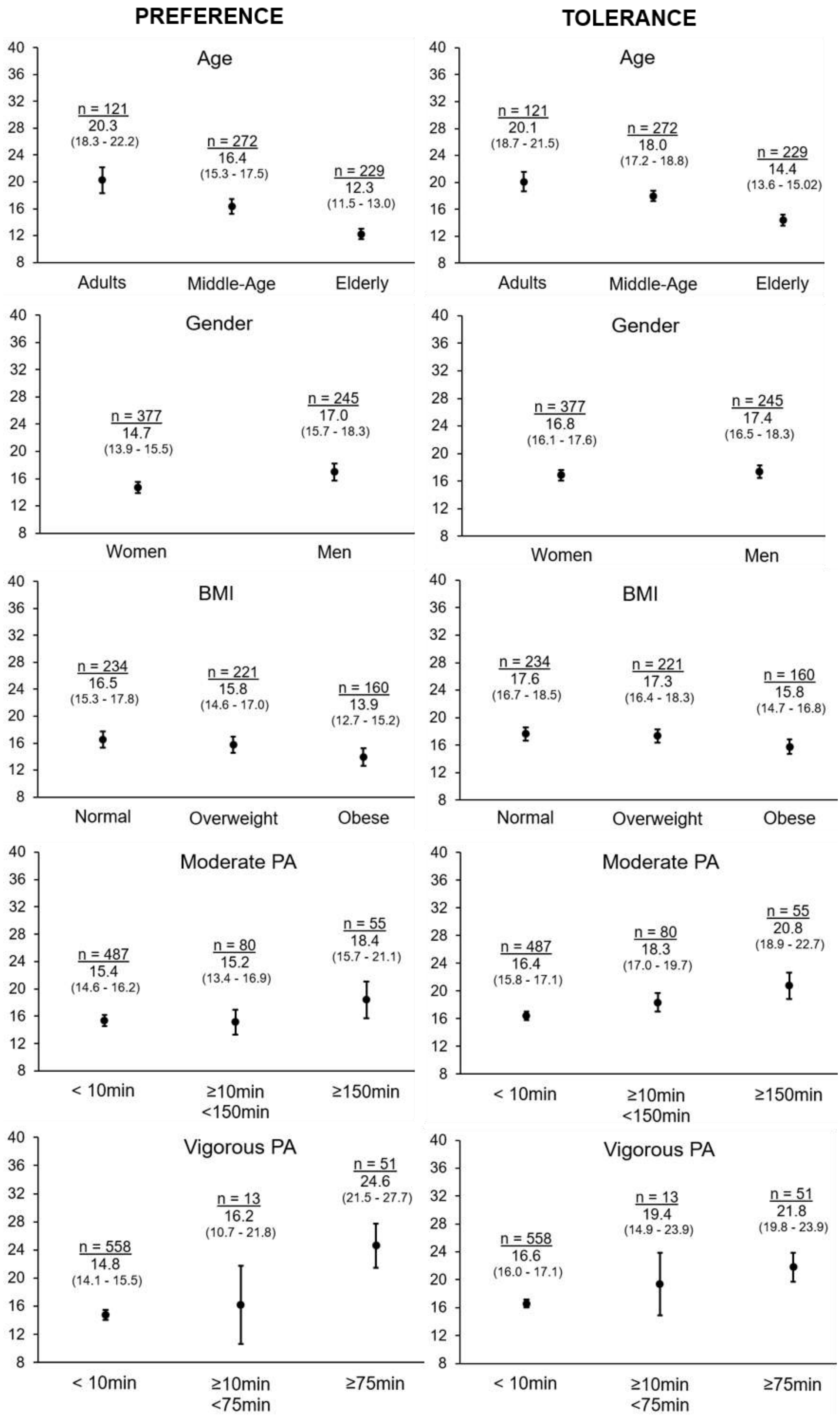

PREFERENCE
TOLERANCE
Age
n = 121
20.3
(18.3 - 22.2)
n = 272
16.4
(15.3 - 17.5)
n = 229
12.3
(11.5 - 13.0)
Adults
Middle-Age
Elderly
Age
n = 121
20.1
(18.7 - 21.5)
n = 272
18.0
(17.2 - 18.8)
n = 229
14.4
(13.6 - 15.02)
Adults
Middle-Age
Elderly
Gender
n = 377
14.7
(13.9 - 15.5)
n = 245
17.0
(15.7 - 18.3)
Women
Men
Gender
n = 377
16.8
(16.1 - 17.6)
n = 245
17.4
(16.5 - 18.3)
Women
Men
BMI
n = 234
16.5
(15.3 - 17.8)
n = 221
15.8
(14.6 - 17.0)
n = 160
13.9
(12.7 - 15.2)
Normal
Overweight
Obese
BMI
n = 234
17.6
(16.7 - 18.5)
n = 221
17.3
(16.4 - 18.3)
n = 160
15.8
(14.7 - 16.8)
Normal
Overweight
Obese
Moderate PA
n = 487
15.4
(14.6 - 16.2)
n = 80
15.2
(13.4 - 16.9)
n = 55
18.4
(15.7 - 21.1)
< 10min
≥10min <150min
≥150min
Moderate PA
n = 487
16.4
(15.8 - 17.1)
n = 80
18.3
(17.0 - 19.7)
n = 55
20.8
(18.9 - 22.7)
< 10min
≥10min <150min
≥150min
Vigorous PA
n = 558
14.8
(14.1 - 15.5)
n = 13
16.2
(10.7 - 21.8)
n = 51
24.6
(21.5 - 27.7)
< 10min
≥10min <75min
≥75min
Vigorous PA
n = 558
16.6
(16.0 - 17.1)
n = 13
19.4
(14.9 - 23.9)
n = 51
21.8
(19.8 - 23.9)
< 10min
≥10min <75min
≥75min

Figure 1. Mean values and 95% confidence intervals of Preference and Tolerance scores for age, gender, body mass index (BMI), and moderate and vigorous physical activity (PA)

Preference and Tolerance scores were then regressed on age, gender, BMI and moderate and vigorous LTPA. The model explained a significant portion of variance in Preference scores (R = 0.48, $F_{[5,609]}$ = 36.41, p < 0.001, R^2 = 0.23, R^2_{adj} = 0.22), with all variables, except moderate LTPA (p = 0.98), significantly contributing to the prediction (p < 0.05). Removing moderate LTPA virtually unaltered the model (R = 0.48, $F_{[4,610]}$ = 45.59, p < 0.001, R^2 = 0.23, R^2_{adj} = 0.23), with age, BMI and the female gender showing an inverse association with Preference scores (Table 1). For the Tolerance scores, the model also explained a significant portion of variance (R = 0.42, $F_{[5,609]}$ = 25.29, p < 0.001, R^2 = 0.17, R^2_{adj} = 0.17), however, only age and moderate and vigorous LTPA significantly contributed to the prediction (p < 0.05). Removing gender and BMI virtually unaltered the model (R = 0.41, $F_{[3,618]}$ = 41.17, p < 0.001, R^2 = 0.17, R^2_{adj} = 0.16), with age showing an inverse association with Tolerance scores (Table 2). The prediction equations for both Preference and Tolerance scores are presented below:

Preference score (predicted) = 26.81 – (0.196 x age) – (0.139 x BMI) + (1.895 x gender*) + (0.035 x vigorous LTPA)

Tolerance score (predicted) = 24.97 – (0.155 x age) + (0.010 x moderate LTPA) + (0.014 x vigorous LTPA)

Age in *years*; BMI in $m \cdot kg^{-1}$; *1* for females and *2* for males; Moderate and Vigorous LTPA (leisure time physical activity) in *minutes*.

Table 1 - Regression values for age, gender, BMI and vigorous leisure-time physical activity (LTPA) on Preference scores.

Variable	Standardized β	t	*p*
Age	-0.331	-9.166	< 0.001
Vigorous LTPA	0.258	7.096	< 0.001
Gender	0.102	2.866	0.004
BMI	-0.08	-2.249	0.025

Table 2 - Regression values for age and moderate and vigorous leisure-time physical activity (LTPA) on Tolerance scores.

Variable	Standardized β	t	*p*
Age	-0.336	-9.003	< 0.001
Vigorous LTPA	0.132	3.527	0.006
Moderate LTPA	0.123	3.314	< 0.001

Given the potential associations between the variables, the Preference and Tolerance scores were partially correlated with its significant predictors (Tables 1 and 2) to ensure independent significance. After all partial correlations were performed, controlling for age, gender, BMI and vigorous LTPA, the Preference scores demonstrated significant and independent associations only with age (r = -0.348, p < 0.001) and vigorous LTPA (r = 0.276, p < 0.001), but not with gender (r = 0.115, p = 0.004) or BMI (r = -0.091, p = 0.025). For the Tolerance scores, in which the controlled variables were age, moderate and vigorous LTPA, significant and independent associations were also found with age (r = -0.341, p < 0.001) and vigorous LTPA (r = 0.140, p < 0.001), but not with moderate LTPA (r = 0.132, p = 0.001).

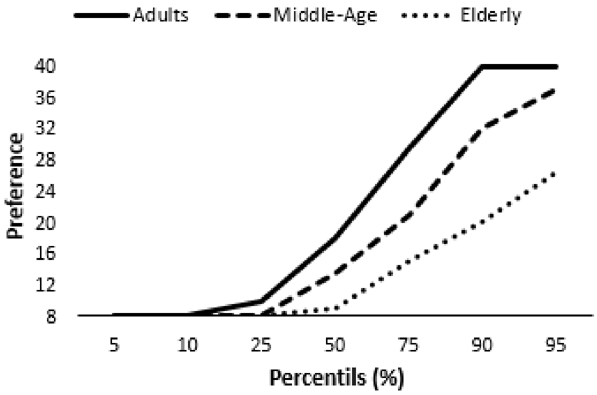
The only two variables significantly and independently associated with the Preference and Tolerance scores were found to be age (r = -0.348 and r = -0.341, respectively) and vigorous LTPA (r = 0.276 and r = 0.140, respectively). As the associations with age were stronger, and only 64 out of 622 individuals reported ≥10min of vigorous LTPA (see Figure 1), normative values for the Preference and Tolerance scores are presented stratified by age categories (Figure 2).

PREFERENCE

		Adults	Middle-Age	Older Adults
n		121	272	229
	5	8	8	8
	10	8	8	8
	25	10	8	8
Percentils	50	18	14	9
	75	30	21	15
	90	40	32	20
	95	40	37	27

TOLERANCE

		Adults	Middle-Age	Older Adults
n		121	272	229
	5	8	8	8
	10	8	8	8
	25	14	13	8
Percentils	50	20	18	13
	75	26	23	19
	90	30	27	24
	95	34	29	25



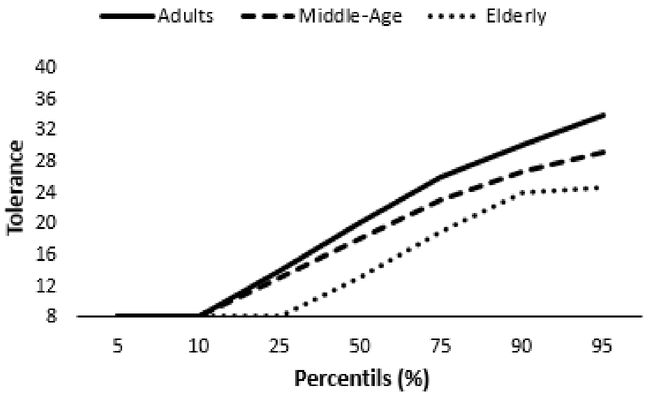


Figure 2. Percentils of Preference and Tolerance scores stratified by age categories

5.3.4. Discussion

Using a diverse population sample in terms of age, gender, BMI and moderate and vigorous LTPA levels, the present study found that the personality traits of Preference for and Tolerance of the intensity of exercise are significantly and independently associated only with age (inversely) and vigorous LTPA (positively). Furthermore, we provide, for the first time, population-based normative values for the Preference and Tolerance scores.

Compiling the results of previous studies investigating the constructs of Preference and Tolerance on specific population subgroups, there was preliminary indication of possible associations with age (Ekkekakis et al., 2006; Ekkekakis, Thome, et al., 2008), gender (Hall et al., 2014; Lochbaum et al., 2009), BMI (Hall et al., 2014) and LTPA (Ekkekakis, Thome, et al., 2008; Hall et al., 2014). The analysis in our population sample confirmed some associations and invalidated others. Age had displayed lower values for both Preference and Tolerance in middle-aged (Ekkekakis et al., 2006) compared to college-aged women (Ekkekakis, Thome, et al., 2008), but in specific samples and with no control over other variables. In our population sample, and controlling for independent associations, we confirmed such inverse association. While LTPA in general had been associated with both Preference and Tolerance in previous studies (Ekkekakis, Thome, et al., 2008), even when controlling for age and BMI (Hall et al., 2014), the present study found that, when stratified for moderate and vigorous LTPA, the only significant and independent associations were found for vigorous LTPA. On the other hand, while men had showed slightly higher values than women (Hall et al., 2014; Lochbaum et al., 2009), controlling for other variables did not confirm this potential association between gender and Preference or Tolerance. Lastly, Hall and colleagues (2014) detected a significant association between BMI and both Preference and Tolerance, even when controlling for age. In contrast, our results demonstrated that BMI was only associated with Preference but after controlling for age, gender and vigorous LTPA, such associations disappeared.

Identifying correlates of Preference and Tolerance of exercise intensity have potential theoretical and practical uses. From a theoretical standpoint, identifying correlates may generate hypotheses about possible causal relationships and about potential mediators (Bauman, Sallis, Dzewaltowski, & Owen, 2002). The observed associations between Preference and Tolerance with vigorous LTPA is not surprising, since the PRETIE-Q has been developed to relate specifically to the intensity of exercise (Ekkekakis et al., 2005). Corroborating evidence comes from previous studies, which identified relationships with the frequency of strenuous but not the frequency of moderate or mild exercise (Ekkekakis, Thome, et al., 2008; Smirmaul et al., 2015). However, determining the direction of such relationship and whether it is causally related is a more difficult task. Those performing more vigorous exercise may perceive, due to a possible better health status and/or fitness level, that they have higher Preference and Tolerance. On the other hand, higher Preference and Tolerance may act as predispositions for more vigorous exercise participation. Preliminary evidence indicates that Preference and Tolerance reflect stable individual differences rather than transient situational appraisals, as demonstrated by no alterations on the scores after a 6-week training program that improved objective and perceived fitness (Hall et al., 2014). Although such information support the latter direction (i.e., Preference and Tolerance as predispositions for more vigorous exercise participation), a lot more ground needs to be covered before we can confidently endorse such claim. The inverse association between Preference and Tolerance with age present a somewhat similar scenario, in which it is currently difficult to ascertain whether there are mediating variables leading to a lower Preference and Tolerance with aging. Interestingly, individual differences in functional and structural markers in the brain's premotor control network have been linked with effort sensitivity and energization to initiate behavior (Bonnelle, Manohar, Behrens, & Husain, 2016). A future line of research may explore, for example, whether aging and chronic adaptations to exercise (especially of vigorous intensity) may alter such functional and structural markers and, still, whether these markers reflect on differences in Preference and Tolerance, affective responses to a range of exercise intensities, and exercise behavior.

From a practical standpoint, determining the factors associated with Preference and Tolerance may help a better tailoring of individual and/or group exercise prescriptions. It has been found, for instance, that individuals with lower Tolerance scores report more aversive affective responses for the same relative exercise intensity than individuals with higher Tolerance scores (Tempest & Parfitt, 2016). Knowing that age and vigorous LTPA are correlates of Tolerance may indicate that a lower relative exercise intensity is likely recommended for middle-aged and older individuals, and/or individuals with no engagement in vigorous activities, in order to optimize affective responses. Preliminary support for such claim has been demonstrated by Frazão and colleagues (2016), in which insufficiently active individuals (reporting low levels of vigorous physical activity) displayed lower affective responses during a high-intensity interval exercise when compared to active individuals (reporting higher levels of vigorous physical activity), even though both groups exercised at the same relative exercise and presented similar physiological and perception of effort responses. Although not measured, the authors speculated that differences in Tolerance of the exercise intensity might explain such results (Frazão et al., 2016).

Although noting that the constructs of Preference and Tolerance could be useful for a better exercise prescription, no attempt has been made by the American College of Sports Medicine to provide recommendations on how to operationalize its utilization on practice (ACSM, 2013). For instance, administering the PRETIE-Q and identifying the Preference and Tolerance scores of individuals would be of limited usefulness unless we are able to evaluate such scores with evidence-based parameters and put them in perspective to provide well-informed recommendations. Thus far, preliminary parameters had been provided only by two studies, which established normative data for college-age women (Ekkekakis, Thome, et al., 2008) and showed that college-aged individuals with low-tolerance (mean score of 21.1) presented worse affective responses than the high-tolerance group (mean score of 33.1) in exercise intensities above the individual ventilatory threshold (Tempest & Parfitt, 2016). In the present study, we add to this body of knowledge by identifying some factors associated and providing population-based normative values for Preference and Tolerance. For instance, future studies can now investigate which magnitude of differences in Preference and Tolerance scores or differences in percentiles are practically relevant in mediating affective responses.

Researchers and practitioners should be aware of the inherent limitations of the present study. First, the cross-sectional design used here has limited efficacy to support causal inferences (Bauman et al., 2002). Second, we used self-report measures for weight and height, as well as moderate and vigorous LTPA, which may bias the findings. Lastly, despite performing independent associations by controlling for a few variables, it is likely that important variables were not included, such as self-efficacy, fitness status and other physiological/psychological variables.

5.3.5. Conclusion

In conclusion, the constructs of Preference for and Tolerance of the intensity of exercise were found to be associated with age (inversely) and vigorous leisure-time physical activity (positively). Furthermore, we provide, for the first time, population-based normative values for the Preference and Tolerance scores.

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5.4. Article 4 – Associations Between Preference for and Tolerance of the Intensity of Exercise and Longitudinal Exercise Behavior

This manuscript will be submitted to a scientific journal after all authors approve the final version.

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ABSTRACT

Purpose: to test whether longitudinal exercise behavior is associated with the constructs of Preference for and Tolerance of exercise intensity in a diverse population sample. Methods: cohort study involving 1588 individuals in 2007-2008 and 693 individuals in 2014-2015. Face-to-face interviews were conducted at the participants' homes in both periods. Assessments included demographic and anthropometric characteristics, leisure-time physical activity in both periods, and the Preference for and Tolerance of the Intensity of Exercise Questionnaire (PRETIE-Q) in 2014-2015. First, a multiple linear regression and partial correlations were performed to evaluate the predictive value of specific variables on total, moderate and vigorous LTPA levels in 2014-2015. Then, multinomial logistic regressions were used to calculate the odds ratio for sedentary, insufficiently active and active exercise behavior in 2007-2008 and 2014-2015. Results: controlling for age, gender, BMI and past LTPA levels, it was found that a 1-unit increase in Preference and/or Tolerance scores is associated with additional ≈5min/week of total LTPA, ≈2min/week of moderate LTPA and ≈2min/week of vigorous LTPA. In addition, considering the recommended levels of LTPA, it was found that a 1-unit increase in Preference and/or Tolerance scores is associated with ≈4-6%, 12.4% and 9.1% greater odds of longitudinally attaining the recommended levels of total, moderate and vigorous LTPA, respectively. Conclusion: it was demonstrated, for the first time, that longitudinal exercise behavior is associated with the constructs of Preference for and Tolerance of the intensity of exercise in a diverse population sample.

5.4.1. Introduction

Given the low levels of exercise participation/adherence in the population, and its relationship with public health, it has been paramount to achieve a better understanding of exercise behavior (Bauman et al., 2012). In this sense, theoretical models are perhaps the best way for adding depth to knowledge and to be comprehensive enough for a more appropriate understanding of the behavior (Biddle & Nigg, 2000; Rhodes & Nigg, 2011). Currently, some of the most popular theoretical models in exercise behavior have adopted a cognitivist paradigm, heavily dependent on collecting information, reasoning pros and cons, and predicting future consequences of behavior (Biddle & Nigg, 2000; Ekkekakis, Hargreaves, & Parfitt, 2013; Rhodes & Nigg, 2011). As previously pointed out (Biddle & Nigg, 2000), these theoretical models have been borrowed from other health-related disciplines and not specifically created to investigate exercise behavior. Unlike other health-related behaviors, such as smoking, drinking alcohol, eating, among others, exercise behavior presents unique characteristics, arguably requiring unique theories (Rhodes & Nigg, 2011). For instance, two of these unique characteristics are highlighted: i) exercise "*places the body in an aversive body state out of homeostasis*" and, ii) "*produces variable affective responses that are dependent on the load and temporal aspects of the act*" (Rhodes & Nigg, 2011).

In fact, the role of pleasure and displeasure have been considered the "*common currency*" for accessing human behavior in general for a long time (Cabanac, 1992; Ramirez & Cabanac, 2003), and the so-called "hedonic theory" has been used extensively in several fields of research (Ekkekakis & Dafermos, 2012; Williams, 2008). Only in the last decade, however, researchers have explored the impact of affective responses on exercise participation and adherence, greatly expanding its understanding and illuminating promising constructs for inclusion on current (or development of new) theoretical models of exercise behavior (Ekkekakis & Dafermos, 2012; Ekkekakis et al., 2013; Rhodes & Kates, 2015; Williams & Evans, 2014; Williams, 2008). For example, a meta-analysis of 82 correlational studies on affective judgments and physical activity found a medium-to-large effect size of 0.42, higher than effect sizes commonly found for self-efficacy, which is widely regarded as the variable best correlated with exercise behavior (Rhodes, Fiala, & Conner, 2009). Still, more convincing evidence has been provided by a handful of studies showing that affective responses experienced during exercise predicts current and/or future exercise behavior (Kwan & Bryan, 2010; Schneider, Dunn, & Cooper, 2009; Williams et al., 2008; Williams, Dunsiger, Jennings, & Marcus, 2012), with effect sizes ranging from 0.18 to 0.51 (Rhodes & Kates, 2015).

Importantly, affective responses during exercise present large interindividual variability, even when intensity is normalized for the fitness level of each individual or factors such as age, gender or exercise experience are taken into account (for a review see Ekkekakis, Parfitt, & Petruzzello, 2011). Several individual-difference variables are likely to have an influence, such as self-efficacy, motivational states, perceived autonomy, among others (Ekkekakis et al., 2013). In understanding this large interindividual variability, the personality traits of preference for and tolerance of exercise intensity have been particularly encouraging, as they correlate with affective responses during exercise (Ekkekakis, Hall, & Petruzzello, 2005) and it has been found that, despite similar fitness level and for the same relative exercise intensity, individuals with higher tolerance report more positive affective responses when compared to those with lower tolerance (Tempest & Parfitt, 2016). Given the rationale above developed regarding the relationship with affective responses and exercise behavior, it is hypothesized that the levels of preference and tolerance may partially explain exercise behavior, once individuals with low levels of preference and tolerance are likely to experience more aversive responses (unpleasant feelings) during exercise (Tempest & Parfitt, 2016), thus tending to avoid repeating such behavior.

Therefore, the purpose of this study is to test whether longitudinal exercise behavior is associated with the constructs of preference for and tolerance of exercise intensity in a diverse population sample.

5.4.2. Methods

This cohort population study was conducted in the city of Rio Claro, in southeastern Brazil, 180 kilometers from the capital of São Paulo. The city covers a land area of approximately 498 km^2, with a population density of 373 habitants/km^2, a total population of 186,253 people, and a Human Development Index of 0.803 (Atlas do Desenvolvimento Humano no Brasil, 2013).

Procedures

In 2007-2008, a stratified random sampling procedure was used to select a representative sample of adults (20 years or older) living in the city of Rio Claro, resulting in a sample of 1588 individuals interviewed. Detailed information regarding data collection is provided in previously published articles from the 2007-2008 study (Nakamura et al., 2014; Sebastião et al., 2012, 2013). In 2014-2015, the follow-up stage of the aforementioned study was conducted.

From the original 1588 participants in 2007-2008, 693 were contacted and successfully interviewed in 2014-2015. Briefly, participants lost to follow-up included those who changed address and could not be found (n = 342), those who refused to participate (n = 144), those who died (n = 81), among others. Face-to-face interviews were conducted at the participants' homes for both stage (2007-2008 and 2014-2015). While in 2007-2008 pen and paper were used for the questionnaires, in 2014-2015 the interviews were done using an electronic questionnaire format on tablets running the Open Data Kit (ODK) app. All participants signed a consent form prior to participation, which had been approved by the local Ethics Committee for the 2007-2008 study (No. 0848) and for the 2014-2015 study (No. 430.908) according to the standards set by Resolution 196/96 and 466/12, respectively.

Questionnaires

A survey including basic demographic and self-reported anthropometric information such as age, weight, and height was administered both in 2007-2008 and in 2014-2015. As the 2007-2008 study involved only adults >20 years, age categories for the follow-up in 2014-2015 were: adults (26-39 years); middle-age adults (40-59 years); and older adults (> 60 years). Weight and height were used to calculate the body mass index (BMI), which was categorized as: normal-weight ($\leq$ 24.99 $kg \cdot m^{-1}$); overweight (25.00-29.99 $kg \cdot m^{-1}$); or obese ($\geq$ 30.00 $kg \cdot m^{-1}$).

Leisure-time physical activity (LTPA) of moderate and vigorous intensity was assessed both in 2007-2008 and in 2014-2015 by the International Physical Activity Questionnaire (IPAQ) - long version, translated and validated for the Brazilian population (Matsudo et al., 2001). Questions assessing both moderate- and vigorous-intensity PA referred to the week prior to the interview, with a minimum duration of at least 10 minutes per session. Moderate (< 10min; ≥ 10min < 150min; ≥ 150min) and vigorous (< 10min; ≥ 10min < 75min; ≥ 75min) LTPA were categorized according to global recommendations for health (WHO, 2010).

The Preference for and Tolerance of the Intensity of Exercise Questionnaire (PRETIE-Q) (Ekkekakis et al., 2005) was administered only in 2014-2015. The PRETIE-Q consists of two 8-item scales, namely Preference and Tolerance, in which each item is accompanied by a 5-point response scale. The Preference scale contains four items that measure preference for high-intensity (Items 6, 10, 14, 16) and four that measure preference for low-intensity exercise (Items 2, 4, 8, 12). Similarly, the Tolerance scale contains four items that measure high tolerance (Items 5, 7, 11, 15) and four that measure low tolerance of high exercise intensity (Items 1, 3, 9, 13). Items indicative of preference for low intensity (Items 2, 4, 8, 12) and items indicative of low tolerance (Items 1, 3, 9, 13) are reversed-scored. Thus, the possible score range for each scale is 8-40. For the present study, the Brazilian Portuguese adaptation of the PRETIE-Q was used (Smirmaul, Ekkekakis, Teixeira, Nakamura, & Kokubun, 2015), and its application followed the same procedures from our previous structural validity study (Article 2 from this PhD Thesis).

Data Analysis

Firstly, a multiple linear regression was conducted to evaluate the predictive value of LTPA levels from 2007-2008, age, gender, BMI and Preference and Tolerance scores from 2014-2015 on total, moderate and vigorous LTPA levels in 2014-2015. In addition, partial correlations were performed between the significant predictor variables and the total, moderate and vigorous LTPA levels from 2014-2015, in order to ensure independent associations. Significance was set at $p < 0.05$ for multiple linear regressions and at $p < 0.001$ for partial correlations, in order to control for the multiple comparisons problem. For the second analysis, which involved the exercise behavior in 2007-2008 and in 2014-2015, multinomial logistic regressions were used to calculate the odds ratio (OR) and associated 95% confidence intervals of individuals' behavior for performing total, moderate or vigorous LTPA between 2007-2008 and 2014-2015 according to their age, gender, BMI, and Preference and Tolerance scores from 2014-2015. LTPA behavior was divided in 3 categories: i) Sedentary (reference category) – <10min minutes/week of LTPA in both 2007-2008 and 2014-2015; ii) Insufficiently Active – ≥10min/week but not attaining the recommended level of LTPA in 2007-2008 and/or 2014-2015; iii) Active – equal to or above the recommended levels of LTPA in both 2007-2008 and 2014-2015 (Table 2). Recommended levels of LTPA were considered as ≥150min/week of total or moderate LTPA, or ≥75min/week of vigorous LTPA. Total LTPA was calculated as: (minutes of moderate LTPA x 1) + (minutes of vigorous LTPA x 2). Age, BMI, Preference and Tolerance scores from 2014-2015 were entered as continuous variables, while gender was entered as categorical variable. Interpretation of the results was made by both the 95% confidence intervals and the significance set at $p < 0.05$.

5.4.3. Results

Total, moderate and vigorous leisure-time physical activity (LTPA) levels in 2014-2015 were regressed on LTPA in 2007-2008, age, gender, BMI, preference and tolerance scores from 2014-2015. The model for total LTPA explained a significant portion of variance (R = 0.40, $F_{[6,608]} = 19.05$, $p < 0.001$, $R^2 = 0.16$, $R^2_{adj} = 0.15$), with only BMI not significantly contributing to the prediction ($p = 0.40$). Removing BMI virtually unaltered the model (R = 0.40, $F_{[5,616]} = 23.08$, $p < 0.001$, $R^2 = 0.16$, $R^2_{adj} = 0.15$), with the female gender showing a negative association with total LTPA. The model for moderate LTPA explained a significant portion of variance (R = 0.25, $F_{[6,608]} = 6.73$, $p < 0.001$, $R^2 = 0.06$, $R^2_{adj} = 0.05$), with moderate LTPA from 2007-2008, age and tolerance scores significantly contributing to the prediction ($p < 0.05$). Removing gender, BMI and preference scores virtually unaltered the model (R = 0.24, $F_{[3,618]} = 12.24$, $p < 0.001$, $R^2 = 0.06$, $R^2_{adj} = 0.05$). The model for vigorous LTPA explained a significant portion of variance (R = 0.40, $F_{[6,608]} = 19.42$, $p < 0.001$, $R^2 = 0.16$, $R^2_{adj} = 0.15$), with only vigorous LTPA from 2007-2008 and preference scores significantly contributing to the prediction ($p < 0.05$). Removing age, gender, BMI and tolerance scores virtually unaltered the model (R = 0.40, $F_{[2,619]} = 57.83$, $p < 0.001$, $R^2 = 0.16$, $R^2_{adj} = 0.16$). The prediction equations for total, moderate and vigorous LTPA are presented below:

Total LTPA predicted = -245.109 + (0.176 x total LTPA from 2007-2008) + (40.949 x gender) + (2.651 x age) + (4.589 x Preference) + (5.067 x Tolerance)

Moderate LTPA predicted = -56.053 + (0.053 x moderate LTPA from 2007-2008) + (0.980 x age) + (1.949 x Tolerance)

Vigorous LTPA predicted = -20.885 + (0.148 x vigorous LTPA from 2007-2008) + (2.267 x Preference)

Total LTPA from 2007-2008 in minutes; *1* for females and *2* for males; age in years; Preference and Tolerance scores in arbitrary units

Given the potential associations between the variables, total, moderate and vigorous LTPA were partially correlated with its significant predictors to ensure independent significance. After all partial correlations were performed, total LTPA demonstrated significant and independent associations with total LTPA from 2007-2008, age and Preference scores (all $p < 0.001$), but not with gender ($r = 0.085$, $p = 0.034$). For moderate LTPA, significant and independent associations were found for age and Tolerance scores (all $p < 0.001$), but not for moderate LTPA from 2007-2008 ($r = 0.099$, $p = 0.014$). Lastly, for vigorous LTPA, significant and independent associations were found for both vigorous LTPA from 2007-2008 and Preference scores (all $p < 0.001$). All regression values and partial correlations are presented in Table 1.

Table 1 - Regression values and partial correlations of the significant predictor variables for total, moderate and vigorous leisure-time physical activity (LTPA).

		TOTAL LTPA			
Variable	Unstandardized B	t	*p*	r_{PART}	*p*
Total LTPA 2007-2008	0.176	5.519	< 0.001	**0.217**	**< 0.001**
Gender	40.949	2.129	0.034	0.085	0.034
Age	2.615	4.336	< 0.001	**0.172**	**< 0.001**
Preference	4.589	3.730	< 0.001	**0.149**	**< 0.001**
Tolerance	5.067	3.286	0.001	0.131	0.001
		MODERATE LTPA			
Variable	Unstandardized B	t	*p*	r_{PART}	*p*
Total LTPA 2007-2008	0.053	2.464	0.014	0.099	0.014
Age	0.980	4.244	< 0.001	**0.168**	**< 0.001**
Tolerance	1.949	3.909	< 0.001	**0.155**	**< 0.001**
		VIGOROUS LTPA			
Variable	Unstandardized B	t	*p*	r_{PART}	*p*
Total LTPA 2007-2008	0.148	6.006	< 0.001	**0.235**	**< 0.001**
Preference	2.267	8.189	< 0.001	**0.313**	**< 0.001**

Exercise Behavior (2007-2008 and 2014-2015)

The prevalence of total, moderate and vigorous LTPA levels according to the 3 behavior categories (sedentary, insufficiently active, active) between 2007-2008 and 2014-2015 are presented in Table 2.

Table 2 - Leisure-time physical activity levels according to their 3 behavior categories.

	Total LTPA	Moderate LTPA	Vigorous LTPA
Sedentary	248 (39.9%)	334 (53.7%)	521 (83.8%)
Insufficiently Active	301 (48.4%)	268 (43.1%)	85 (13.7%)
Active	73 (11.7%)	20 (3.2%)	16 (2.5%)
Total	622 (100%)	622 (100%)	622 (100%)

Table 3 depicts all odds ratios with its associated 95% confidence intervals and *p* values, when comparing the longitudinally active and insufficiently active behaviors between 2007-2008 and 2014-2015, with the longitudinally sedentary behavior (reference group). For total LTPA, the only variable associated with the insufficiently active behavior was age, with a 1-year increase in age expected to increase in 1.4% the odds of being insufficiently active longitudinally. Still for total LTPA, the active behavior was associated with both the Preference and Tolerance scores, with a 1-unit increase expected to increase in 4% and 5.9% the odds of being active longitudinally, respectively. For moderate LTPA, none of the independent variables was associated with the insufficiently active behavior. On the other hand, the active behavior was associated with the Tolerance scores, with a 1-unit increase expected to increase in 12.4% the odds of being active longitudinally. Lastly, for vigorous LTPA, both gender and Preference were associated with the insufficiently active behavior, with the female group expected to reduce the odds in 39.2%, and with a 1-unit increase in the Preference scores expected to increase in 3.9% the odds of being insufficiently active longitudinally. The active behavior was associated only with the Preference scores, with a 1-unit increase expected to increase in 9.1% the odds of being active longitudinally.

Table 3 - Odds ratio (OR) for total, moderate and vigorous leisure-time physical activity (LTPA) from 2007-2008 to 2014-2015 according to age, gender, BMI, Preference and Tolerance scores.

	TOTAL LTPA			**MODERATE LTPA**			**VIGOROUS LTPA**		
	OR	**95% CI**	**p**	**OR**	**95% CI**	**p**	**OR**	**95% CI**	**p**
Insufficiently Active									
Age	**1.014***	(1.002 - 1.026)	0.018	1.009	(0.998 - 1.020)	0.103	1.012	(0.996 - 1.028)	0.129
Gender									
Males	1			1			1		
Females	0.740	(0.517 - 1.059)	0.100	0.797	(0.569 - 1.117)	0.188	**0.608***	(0.376 - 0.981)	0.042
IMC	0.994	(0.962 - 1.028)	0.728	0.998	(0.967 - 1.029)	0.886	0.998	(0.952 - 1.045)	0.929
Preference	1.018	(0.994 - 1.042)	0.145	1.010	(0.989 - 1.032)	0.346	**1.039***	(1.010 - 1.067)	0.007
Tolerance	1.022	(0.992 - 1.052)	0.150	1.015	(0.987 - 1.043)	0.290	1.036	(0.998 - 1.076)	0.061
Active									
Age	1.015	(0.997 - 1.033)	0.107	1.017	(0.987 - 1.048)	0.260	0.975	(0.940 - 1.011)	0.168
Gender									
Males	1			1			1		
Females	0.693	(0.398 - 1.207)	0.195	0.613	(0.240 - 1.566)	0.306	0.568	(0.198 - 1.632)	0.293
IMC	1.028	(0.979 - 1.080)	0.270	1.037	(0.955 - 1.125)	0.391	1.011	(0.931 - 1.110)	0.817
Preference	**1.040***	(1.007 - 1.075)	0.018	1.013	(0.959 - 1.069)	0.649	**1.091***	(1.035 - 1.150)	0.001
Tolerance	**1.059***	(1.014 - 1.107)	0.009	**1.124***	(1.046 - 1.208)	0.002	1.045	(0.967 - 1.130)	0.264

Reference category is *Sedentary*.
* $p < 0.05$

Comparing the active group with the insufficiently active group (as reference), the only association found was for Tolerance scores (OR = 1.107 [95% CI = 1.030 - 1.190], p = 0.006) in the moderate LTPA, with a 1-unit increase expected to increase in 10.7% the odds of being active longitudinally.

5.4.4. Discussion

It was found, for the first time, that longitudinal exercise behavior is associated with the constructs of Preference for and Tolerance of the intensity of exercise in a diverse population sample. Despite controlling for age, gender, BMI and past LTPA, the only variables associated in every category of PA (total, moderate and vigorous) were the constructs of Preference and/or Tolerance.

In college-age participants, and with no control over any confounding variables, previous studies have identified cross-sectional correlations between Preference and Tolerance and self-reported total and strenuous LTPA ranging from 0.18 to 0.49 (Ekkekakis, Thome, Petruzzello, & Hall, 2008; Smirmaul et al., 2015), with no significant correlations for moderate or mild LTPA. In addition, cross-sectional correlations of ≈0.28 were also found for Preference/Tolerance and physical activity when controlling for age and BMI (Hall, Petruzzello, Ekkekakis, Miller, & Bixby, 2014). The present results expands these preliminary cross-sectional correlations demonstrating that, with all other variables kept constant (age, gender, BMI and past LTPA levels), a 1-unit increase in Preference and/or Tolerance scores is associated with additional ≈5min/week of total LTPA, ≈2min/week of moderate LTPA and ≈2min/week of vigorous LTPA. Still, considering the recommended levels of LTPA, it was found that a 1-unit increase in Preference and/or Tolerance scores is associated with ≈4-6%, 12.4% and 9.1% greater odds of longitudinally attaining the recommended levels of total, moderate and vigorous LTPA, respectively.

In light of the emerging "hedonic theory" more recently applied to exercise behavior (Ekkekakis & Dafermos, 2012; Ekkekakis et al., 2013; Williams & Evans, 2014; Williams, 2008), the main variable under investigation has been the affective responses to exercise (Rhodes & Kates, 2015). It has been showed that affective responses to an acute bout of exercise are able to concurrently or prospectively explain 8-11% of the variance in 6 and 12-month physical activity (Williams, 2008), 4 additional daily minutes for each unit increase in affective responses in adolescents (Schneider et al., 2009), 1-6% of variance in exercise behavior after 3 months (Kwan & Bryan, 2010), and an additional 15min/week 6 months later for each unit increase in affective responses in healthy adults (Williams et al., 2012). As the constructs of Preference and Tolerance of exercise intensity are important sources of the high interindividual variability of affective responses to exercise (Ekkekakis et al., 2005; Tempest & Parfitt, 2016), the associations between Preference and Tolerance with exercise behavior were also expected. For instance, individuals with higher Tolerance scores (mean value of 33 on a possible range from 8 to 40) reported better affective responses during exercise (1-2 units higher) when compared to individuals with lower Tolerance scores (mean value of 21) (Tempest & Parfitt, 2016). In light of the present results, the difference of 12 points in the Tolerance scores between the groups (Tempest & Parfitt, 2016) is estimated to translate in an additional 24min/week of moderate LTPA. Similarly, the better affective responses reported (1-2 units higher) for the higher Tolerance group (Tempest & Parfitt, 2016) is estimated to translate in an additional 15-30min/week 6 months later (Williams et al., 2012).

Although other variables are also hypothesized to mediate the affective responses to exercise, such as self-efficacy, motivational states, perceived autonomy, among others (Ekkekakis et al., 2013), the reported associations between Preference and Tolerance scores and exercise behavior revealed here allow such constructs to be used, if not interchangeably, as a proxy of affective responses in future studies. For instance, while the measurement of affective responses require an exercise bout to be performed (Rhodes & Kates, 2015), Preference and Tolerance scores can be assessed by administering a ≈3min long questionnaire (Ekkekakis et al., 2005; Smirmaul et al., 2015). As the investigations on both affective responses and Preference and Tolerance of exercise intensity continue, it would be interesting to include such constructs on theoretical models of exercise behavior, alongside well-known correlates (Bauman et al., 2012).

In interpreting the findings of the present study, it is important to be aware of a few limitations. First, self-report measures for weight and height, as well as LTPA levels were used, which may bias the findings. Second, Preference and Tolerances scores only from 2014-2015 were used. Although preliminary evidence indicates that Preference and Tolerance reflect stable individual differences rather than transient situational appraisals, as demonstrated by no alterations on the scores after a 6-week training program that improved objective and perceived fitness (Hall et al., 2014), we are not able to ascertain whether such values changed from 2007-2008 to 2014-2015, and whether these possible changes might have influenced the exercise behavior. Lastly, despite controlling for age, gender, BMI and past LTPA levels, it is likely that important variables were not included, such as self-efficacy, fitness status and other physiological/psychological variables.

5.4.5. Conclusion

In conclusion, longitudinal exercise behavior is associated with the constructs of Preference for and Tolerance of the intensity of exercise in a diverse population-based sample. A 1-unit increase in Preference and/or Tolerance scores were associated with additional 2-5min/week of LTPA, and with 4-12% increased odds of longitudinally attaining the recommended of LTPA.

5.4.6. References

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6. ADDITIONAL ACTIVITIES DURING MY PHD

Publications

Peer-Reviewed Articles (2013-2016)

1) SMIRMAUL, B. P. C.. Pre-task music and sports and exercise performance ? a literature review. Journal of Sports Medicine and Physical Fitness (Testo stampato), 2016. (In Press)

2) SMIRMAUL, B. P. C.; SANTOS, R. V. ; SILVA NETO, L. V. . Pre-task music improves swimming performance. Journal of Sports Medicine and Physical Fitness (Testo stampato), v. 55, p. 1445-1451, 2015.

3) TEIXEIRA, I. P. ; SMIRMAUL, B. P. C. ; LUCHINI, P. E. H. ; GOBBI, R. B. ; MOURA, L. P. ; FERNANDES, R. A. . Use of statistics in Physical Education: analysis of national publications between 2009 and 2011 [In Portuguese]. Brazilian journal of physical education and sport, v. 29, p. 139-147, 2015

4) SMIRMAUL, B. P. C.; EKKEKAKIS, P. ; TEIXEIRA, I. P. ; NAKAMURA, P. M. ; KOKUBUN, E. . Preference for and Tolerance of the Intensity of Exercise questionnaire: Brazilian Portuguese version. Revista Brasileira de Cineantropometria & Desempenho Humano (Online), v. 17, p. 550-564, 2015.

5) SMIRMAUL, B. P. C.. Feedback from group III/IV muscle afferents is not the sensory signal for perception of effort. Experimental Physiology (Print), v. 99, p. 835-835, 2014.

6) SILVA NETO, L. V. ; SMIRMAUL, B. P. C. ; PIGNATA, B. H. ; ANDRIES JUNIOR, O. Effect of swimming on the cycling and running performances during the super-sprint triathlon [In Portuguese]. Journal of Physical Education (UEM. Online), v. 25, p. 45-51, 2014.

7) PEREIRA, GLEBER ; SOUZA, DOUGLAS MARTINS DE ; REICHERT, FELIPE FOSSATI ; SMIRMAUL, BRUNO PAULA CARAÇA . Evolution of perceived exertion concepts and mechanisms: a literature review. Brazilian Journal of Kinanthropometry and Human Performance, v. 16, p. 579-587, 2014.

8) NAKAMURA, PRISCILA MISSAKI ; TEIXEIRA, INAIAN PIGNATTI ; SMIRMAUL, BRUNO PAULA ; SEBASTIÃO, EMERSON ; PAPINI, CAMILA BOSQUIERO ; GOBBI,

SEBASTIÃO ; KOKUBUN, EDUARDO . Health related quality of life is differently associated with leisure-time physical activity intensities according to gender: a cross-sectional approach. Health and Quality of Life Outcomes, v. 12, p. 98, 2014.

9) SMIRMAUL, B. P. C.; BERTUCCI, D. R. ; TEIXEIRA, I. P. . Is the VO2max that we measure really maximal?. Frontiers in Physiology, v. 4, p. 1-4, 2013.

10) TEIXEIRA, I. P. ; NAKAMURA, P. M. ; SMIRMAUL, B. P. C. ; FERNANDES, R. A. ; KOKUBUN, E. . Factors associated with the bicycle use for transportation in a medium-sized city [In Portuguese]. Brazilian Journal of Physical Activity and Health, v. 18, p. 698-710, 2013.

11) SMIRMAUL, BRUNO PAULA CARAÇA; Dantas, José Luiz ; NAKAMURA, FÁBIO YUZO ; PEREIRA, GLEBER . The psychobiological model: a new explanation to intensity regulation and (in)tolerance in endurance exercise. Brazilian journal of physical education and sport, v. 27, p. 333-340, 2013.

Book Chapter

1) BERTUCCI, D. R. ; SOUZA, N. M. F. ; SMIRMAUL, B. P. C. . Exercise and Diabetes Mellitus. In: Ferraresi, C; Parizatto, NA. (Org.). Muscle Strength Development, Assessment and Role in Disease. 1ed.New York: Nova Publishers, 2013, p. 153-176.

Abstracts Published in Conference Proceedings

2013-2016 - 15 abstracts

Scientific Presentations (talks, courses, trainings, etc)

2016 - "Training loads monitoring for sport and health"

2014 - "Caffeine and exercise in hypoxia: effects in peripheral and central fatigue"

2014 - "Activities from the Physical Activity Program for the Elderly"

2014 - "Physical activity and health"

2014 - "What is science?"

2014 - "Statistics: central limit theorem, z-score, standard error, confidence intervals"

2014 - "Statistics: concepts, types of data, statistical models, standard deviation"

2014 - "Mental tolerance: a new perspective for aerobic training"

2014 - "Exercise program in health care units"

2014 - "Present, past and future of physical activity interventions in Health Care Units"

2014 - "Statistics: normality tests, correlation, comparison of 2 means, comparison of 3 or more means"

2013 - "How to utilize our research in practice"

2013 - "Training on methods and techniques of research on exercise physiology and health"

Reviewer of Scientific Journals

1) Brazilian Journal of Kinanthropometry and Human Performance

2) Frontiers in Physiology

3) Motriz - Journal of Physical Education

4) Journal of Sports Sciences

5) Brazilian journal of physical education and sport

Supervisor or Co-supervisor of Scientific Projects

1) 2013 – Supervisor of 1 undergraduate student

2) 2015 – Co-supervisor of 2 undergraduate students

Scientific Events

2013-2016 – Participation in 12 events

2013-2016 – Organization of 10 events

Courses and Training (participation)

2014 - Course: "Systematic Review and Meta-Analysis" (20h)

2014 - Course: "Physical Activity and Public Health" - Brazilian Society of Physical Activity and Health (50h)

Institutional/Academic Participation

2013-2014 - Leadership in the community-based "Physical Activity Program for the Elderly" (Programa de Atividade Física para a Terceira Idade - PROFIT)

2013-2016 - Colaboration in the community-based "Exercise in the Health Care Units" program (Programa de Exercícios Físicos em Unidades de Saúde)

2014-2015 - Member of the institutional Postgraduate Program Committee of Scholarships

2014-2016 - Leadership in the weekly scientific meetings (study group) of the laboratory

7. ANNEXES

Ethics Approval

"FACULDADE DE CIÊNCIAS
CAMPUS DE BAURU/ UNESP -
""JÚLIO DE MESQUITA

Continuação do Parecer: 430.908

Comentários e Considerações sobre a Pesquisa:

Nada a considerar.

Considerações sobre os Termos de apresentação obrigatória:

Nada a considerar.

Recomendações:

Conclusões ou Pendências e Lista de Inadequações:

Nada a considerar.

Situação do Parecer:

Aprovado

Necessita Apreciação da CONEP:

Não

Considerações Finais a critério do CEP:

Projeto considerado aprovado por estar em conformidade com os parâmetros legais, metodológicos e éticos analisados pelo colegiado.

BAURU, 21 de Outubro de 2013

Assinador por:
Ari Fernando Maia
(Coordenador)

Endereço: Av. Luiz Edmundo Carrijo Coube, nº 14-01
Bairro: **CEP:** 17.033-360
UF: SP **Município:** BAURU
Telefone: (143)103--6087 **Fax:** (143)103--6087 **E-mail:** arimaia@fc.unesp.br

Consent Form

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

Título da pesquisa: **TRADUÇÃO E ADAPTAÇÃO CULTURAL DE UM QUESTIONÁRIO DE PREFERÊNCIA DE INTENSIDADE E TOLERÂNCIA AO EXERCÍCIO FÍSICO, E SUA APLICAÇÃO PARA VERIFICAR PADRÕES POPULACIONAIS**

Pesquisador responsável**: Prof. Me. Bruno de Paula Caraça Smirmaul**
Orientador: **Eduardo Kokubun**

Núcleo de Atividade Física, Esporte e Saúde - NAFES
Departamento de Educação Física – UNESP/IB/Rio Claro

Identificação do participante

Nome:____

Data de nascimento: ______/______/ ________ **Fone: (** ____ **)** ________ - ___________

Endereço:____

Cidade:____________________________ **UF:** ________ **CEP:** __________ - _________

Eu ____, R.G.____________________, entendo que fui convidado a participar de projeto de pesquisa que será realizado pelo Núcleo de Atividade Física, Esporte e Saúde (NAFES) do Departamento de Educação Física da UNESP/IB/Rio Claro. Ao concordar com a participação desse estudo estou ciente que irei responder um questionário de preferência de intensidade e tolerância ao exercício físico. Entendo que essa atividade apresenta riscos desprezíveis (possível constrangimento ou recusa a participar) e que poderei desistir a qualquer momento do estudo sem nenhum prejuízo à minha pessoa.

Estou ciente que todas as informações cedidas ou coletadas durante os testes serão mantidas em sigilo e não serão divulgadas, exceto para o próprio voluntário, caso requisite. Quando da utilização dos dados para pesquisa, será resguardada a identidade dos participantes. Estou ciente que não haverá qualquer tipo de pagamento pelos participantes (voluntários) da pesquisa, bem como de ressarcimento financeiro pela participação na pesquisa.

Também fui informado que posso requisitar informações adicionais ao estudo a qualquer momento. Tanto o pesquisador como o Comitê de Ética local estarão disponíveis para responder às minhas questões e preocupações. Entendo que a participação nesse projeto de pesquisa é voluntária e que posso recusar ou retirar meu consentimento a qualquer momento, sem comprometer quaisquer atendimentos ou informações necessárias. Li e entendi as informações precedentes, as quais foram devidamente explicadas, bem como, eu e os responsáveis pelo projeto já discutimos todos os riscos e benefícios decorrentes deste, sendo que as dúvidas futuras, que possam vir a ocorrer, poderão ser prontamente esclarecidas, bem como o acompanhamento dos resultados obtidos durante a coleta de dados.

Rio Claro, _____ de ___________ de 2013.

____

Sr(a). Voluntário(a)

____

Prof. Me. Bruno de P. C. Smirmaul (Pesquisador)

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