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The Effect of Acute Voluntary Exercise Session on Pain Threshold and Tolerance in Middle-Aged Tennis Players

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Özet

Aim: The purpose of this study is to examine the alterations in pain threshold and tolerance of middle-aged persons those who regularly play tennis at rest and following acute voluntary exercise.

Methods: Fifty-nine recreationally-active persons aged 30-60 years participated in this study. Women and men separately were divided into 10-years groups, with 30-39, 40-49 and 50-59 years of age. Pressure pain threshold (PPT) and pain tolerance (PPT) measurements were recorded at rest and immediately following an acute exercise. PPT and PPTO values were measured from the biceps muscle of dominant arm by using a digital algometer. Singles tennis match was used as an acute voluntary exercise session, the duration of each tennis match (min) and rate of perceived exertion (RPE) were recorded.

Results: No statistical differences were found in exercise duration or RPE scores among groups. RPE scores showed that tennis match played by participants was corresponded a strenuous exercise session. In all age groups, no statistical differences were found in baseline PPT or PPTO results in women or men. PPT and PPTO values were increased following exercise both in women and men. Although post-exercise PPT results were similar among age groups of women and men, PPTO values of men were found to be higher in all age groups of men in comparison with the same age groups of women.

Conclusion: In conclusion, the present study revealed that one bout of voluntary exercise session resulted in gender-dependent differences in pain tolerance in middle-aged participants, and those middle-aged men were tolerated of pain at higher pressure levels following exercise in comparison with women at the same age.

Keywords
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INTRODUCTION

Exercise-induced hypoalgesia (EIH) is a phenomenon that occurs a decrease in pain sensitivity to a noxious stimulus following exercise (Koltyn, 2000). Various pain induction methods have been widely used to demonstrated EIH in humans and animal models of pain such as thermal (Kemppainen, Hämäläinen & Könönen, 1988; Ruble, Hoffman, Shepanski, Valic, Buckwalter, Clifford, 2005); Özkaya, Aksoy-Gündoğdu, Seyran, Hindistan, Pamuk, Özkaya, 2015; Kaplan, Uğurlu, Pamuk, Özdemir, Hindistan & Özkaya, 2014), electrical (Ring, Edwards, Kavussanuet, 2008) and pressure (Gurevich, Kohn & Davis,1994) pain threshold measurements.

The literature data on EIH condensed in young sedentary adults and athletes, however, limited results demonstrated that this phenomenon observes in advanced age (Gibson & Helme, 2001; Edwards, Fillingim & Ness, 2003). Lemley et *al.* showed that EIH occurs in older persons following an acute bout of isometric exercise with an intensity of 25% maxVO_2 (Lemley, Drewek, Hunter & Hoeger, 2014). Previous studies have been published on EIH in middle-aged adults with chronic pain with healthy control groups and it has been demonstrated that EIH persists in both groups following aerobic (Hoffman, Shepanski, MacKenzie & Clifford, 2005; Meeus, Roussel, Truijen & Nijs, 2010) and isometric (Ge, Nie, Graven-Nielsen, Danneskiold-Samsøe & Arendt-Nielsen 2012; Kadetoff 2007) exercise. Analyzing of this phenomenon in middle- and older age humans is particularly important, because, with advancing age, persons may face with several disease states, and chronical pain is being a frequent health-related problem which is young people may deal more easily (Yazici & Mohammadi, 2017) than older people (Gibson & Helme, 2001).

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It has been demonstrated that the EIH phenomenon occurs following various exercise modalities such as aerobic, dynamic and isometric exercise (Naugle, Fillingim & Riley, 2012). The exercise intensity has been demonstrated to affect the response, and the most prominent response seems to be occur in moderate to higher intensities of aerobic exercise (Hoffman, Shepanski, Ruble, Valic, Buckwalter & Clifford, 2004; Koltyn, 2002), but high- and low-intensity (Hoeger, Dicapo, Rasiarmos & Hunter, 2008; Bement, Rasiarmos, DiCapo, Lewis, Keller, Harkins & Hunter, 2009), and longer duration of isometric exercise (Naugle *et al.* 2012). Another factor that should be considered on EIH response is that the exercise is applied forced or voluntarily. Previous reports in animal studies demonstrated that forced exercise gives rise to chronic stress responses in some cases (Leasure & Jones 2008; Moraska, Deak, Spencer, Roth, & Fleshner, 2000), whereas voluntary exercise may also induce a mild to moderate stress response (Ploughman, Granter-Button, Chernenko, Attwood, Tucker, Mearow & Corbett, 2007). To our knowledge, there is a lack of literature findings examining the alterations EIH following a voluntary physical exercise session in middle-aged adults in the point of view of gender and age groups.

The purpose of the present study is to explore the alterations of pain threshold (PPT) and pressure pain tolerance (PPTO) in recreationally active middle-aged persons following an acute bout of voluntary exercise. We used a singles tennis match as an acute exercise modality, and we examined the alterations of pressure pain threshold and tolerance to investigate EIH in stratified groups of age, and gender in middle-aged adults.

METHOD

Participants

Thirty male and 29 female healthy and recreationally active persons have voluntarily participated into this study. Female and male participants were stratified to 3 groups according to their biological age as 30-39, 40-49 and 50-59 years. The inclusion criteria were aged older than 30 years, playing tennis recreationally at least two years, non-smoker, non-user of alcohol, without medical illness, not receiving medication or vitamins, and willing to participate. In the selection of volunteers, it was ensured that the participants do not to exercise at least 1 week before the experimental period. The subjects provided informed consent, and a standardized individual information session was organized by an exercise specialist to instruct the participants on how to apply the exercise session.

The mean and standard deviations of height of the women participants were 1.65±0.08, 1.68±0.05 and 1.66±0.04 m in 30-39, 40-49 and 50-59 years of age groups, respectively. The mean and standard deviations of body mass in the 30-39, 40-49 and 50-59 years of age groups of women were 56±7.04, 67.84±11.3 and 73.43±0.04, respectively. The mean and standard deviations of BMI of the age groups of women were 20.57±2.88, 23.87±3.4 and 26.63±2.53. The mean and standard deviations of height of the men participants were 1.79±0.06, 1.76±0.04 and 1.81±0.03 in 30-39, 40-49 and 50-59 years of age groups, respectively. The mean and standard deviations of body mass in the 30-39, 40-49 and 50-59 years of age groups of men were 76.08±9.47, 83.92±13.64 and 76.08±2.58, respectively. The mean and standard deviations of BMI of the age groups of men were 23.64±1.61, 26.85±2.42 and 25.58±4.24. There were no significant differences in height, body mass or BMI among the study groups.

Acute exercise session: On the day before the start of the acute exercise session, subjects were familiarized with all of the testing procedures, gave their written informed consent, completed medical history forms, and had personal characteristics measured, including height, weight, and body mass via body composition analyzer.

One day after the resting PPT and PPTO measurements were taken, each subject voluntarily played one singles tennis match. A standard 10-min warm-up preceded the start of each match. During all matches, the subjects ingested only water, ad libitum. Round of play began at approximately 18:00 hr. Each match was played on an outdoor, hard-surface court. Match duration and verbally applied RPE (rate of perceived exertion) scale were recorded at the end of the match. A range of 0-10 number ratings scale was used to determine perceived exertion. RPE values demonstrated that the intensity of acute voluntary exercise session was acceptable as strenuous for all participants (Borg, 1982; Novas, Rowbottom & Jenkins, 2003).

Assessment: Height was measured using an ultrasonic height measure (Soehnle-Waagen GmbH & Co. KG). Body mass was measured by using a Body Composition Analyzer (Model TBF-300 TANITA, Tokyo, Japan). Body mass index (BMI) was calculated from the height and body mass ($kg.m^{-2}$) of each participant.

Pressure pain threshold (PPT) and pressure pain tolerance (PPTO) measurement: Pressure pain threshold and tolerance were measured via an algometer (FPIX 50, Wagner Instruments, Greenwich, CT). PPT and PPTO values of participants were obtained from the belly of the biceps muscle of the non-dominant arm. Single measures of both threshold and tolerance were taken at 90-second intervals to prevent habituation (DeWall & Baumeister 2006). PPT and PPTO measurements were repeated at rest, and during 10 min of recovery period following exercise.

Statistical analysis

All results are presented as means ± standard deviation. Statistical analyses were performed by using SPSS software version 23.0 (SPSS Inc., Chicago, USA). The Shapiro-Wilk test was used to test normal distribution for all parameters. Body height, weight, body mass index, exercise duration and rating of perceived exertion showed a normal distribution, and one-way analysis of variance with post-hoc LSD test was used the determine the differences among groups. Baseline and post-exercise PPT and PPTO variables showed a non-normal distribution and the Kruskal-Wallis test was used to analyze the differences among groups in both genders. The Man-Whitney U test was used to analyze the differences between women and men and the Wilcoxon test was used to compare between baseline and post-exercise measurements of PPT and PPTO variables. Due to each gender were stratified by 3 groups in the study, the Bonferroni correction was applied to set the significance criterion to p<0.016 (i.e., 0.05/3).

RESULTS

Mean and standard deviation of exercise duration and rating of perceived exertion (RPE) results are presented in Table 1. No statistically differences were found on exercise duration or RPE scores among groups.

Table 1. Exercise duration (min) and rating of perceived exertion (RPE) scores of all groups.

	Women			Men			
Age Groups (yr)	**30-39 (n=6)**	**40-49 (n=13)**	**50-59 (n=7)**	**30-39 (n=6)**	**40-49 (n=13)**	**50-59 (n=7)**	
Variable	$\bar{X}$**±SS**	$\bar{X}$**±SS**	$\bar{X}$**±SS**	$\bar{X}$**±SS**	$\bar{X}$**±SS**	$\bar{X}$**±SS**	**p**
Exercise Duration(min)	93.83±19.19	84.38± 20.67	78.00± 16.30	80.00±17.16	85.00±18.57	75.75±13.12	0.574
RPE score	7.17±1.72	6.38±1.62	6.29±2.06	5.92±1.44	6.85±1.28	6.00±0.82	0.435

p column shows p values of analysis of variance test results among 3 age groups.

Table 2 shows mean ± standard deviation results for baseline and post-exercise pressure pain threshold (PPT) measurements in groups of women. No statistical differences were found on baseline and post-exercise results of PPT among groups Although there was an increase in PPT following exercise in all age groups, statistically difference was only found in 40-49 years of age group in a comparison with baseline PPT at the same age group (p=0.001).

Table 2. Baseline and post-exercise pressure pain threshold results in groups of women (kg).

	Women			
Age Groups (yr)	**30-39 (n=6)**	**40-49 (n=13)**	**50-59 (n=7)**	
Variable	$\bar{X}$**±SS**	$\bar{X}$**±SS**	$\bar{X}$**±SS**	**p**
Baseline PPT (kg)	1.88±0.97	1.33±0.98	2.74±1.53	0.070
Post-exercise PPT (kg)	3.87±2.2 (p=0.027)	3.59±1.71 **(*p=0.001)**	5.29±1.61 (p=0.028)	0.101

*p=0.001, difference from baseline PPT. p column shows p values of Kruskal-Wallis test results among 3 age groups. PPT: pressure pain threshold.

Table 3 shows mean ± standard deviation results for baseline and post-exercise pressure pain threshold measurements in 3 age groups of men. Statistical analysis showed that there were no differences in baseline or post-exercise PPT results among groups. On the other hand, it was found that all PPT result were found to be increased following exercise. Baseline and post-exercise comparisons were demonstrated significant differences with a p value of 0.001 in 30-39, and 40-49 years of age groups.

Table 3. Baseline and post-exercise pressure pain threshold results in groups of men (kg).

Variable	Age Groups (yr)	Men		
	30-39 (n=6)	40-49 (n=13)	50-59 (n=7)	
	$\bar{X}$±SS	$\bar{X}$±SS	$\bar{X}$±SS	p
Baseline PPT (kg)	2.64±1.86	1.43±0.63	1.33±0.66	0.146
Post-exercise PPT (kg)	6.09±3.62 (***p=0.001**)	3.46±0.82 (***p=0.001**)	4.61±0.54 (p=0.066)	0.033

*p=0.001, difference from baseline PPT. p column shows p values of Kruskal-Wallis test results among 3 age groups. PPT: pressure pain threshold.

Table 4 shows the baseline PPT comparison in 3 age groups of women and men. No statistical differences were found among age groups of women and men.

Table 4. Baseline pressure pain threshold results in groups of women and men (kg).

Variable	Age Groups (yr) 30-39 (n=6)	40-49 (n=13)	50-59 (n=7)	
	$\bar{X}$±SS	$\bar{X}$±SS	$\bar{X}$±SS	p
Women	1.88±0.97	1.33±0.98	2.74±1.53	0.070
Men	2.64±1.86	1.43±0.63	1.33±0.6	0.146

p column shows p values of Kruskal-Wallis test results among 3 age groups.

Table 5 shows the post-exercise PPT comparison in 3 age groups of women and men. No statistical differences were found in PPT results among age groups of women and men.

Table 5. Post-exercise pressure pain threshold results in groups of women and men (kg).

Variable	Age Groups (yr) 30-39 (n=6)	40-49 (n=13)	50-59 (n=7)	
	$\bar{X}$±SS	$\bar{X}$±SS	$\bar{X}$±SS	p
Women	3.87±2.2	3.59±1.71	5.29±1.61	0.101
Men	6.09±3.62	3.46±0.82	4.61±0.54	0.033

p column shows p values of Kruskal-Wallis test results among 3 age groups.

Mean ± standard deviation results for baseline pressure pain tolerance (PPTO) measurements in groups of women and men are presented in Table 6. No statistical difference was found in baseline PPTO measurements in age groups of women or men.

Table 6. Baseline pressure pain tolerance results in groups of women and men (kg).

Variable	Age Groups (yr)	Age Groups		
	30-39 (n=6)	40-49 (n=13)	50-59 (n=7)	
	$\bar{X}$±SS	$\bar{X}$±SS	$\bar{X}$±SS	p
Women	7.41±1.99	5.18±2.38	5.2±1.97	0.098
Men	9.18±3.44	5.97±2.36	7.06±2.26	0.054

p column shows p values of Kruskal-Wallis test results among 3 age groups.

Mean ± standard deviation results for post-exercise pressure pain tolerance measurements in groups of women and men are presented in Table 7. In all age groups, men had higher PPTO measurements in comparison with the same age group of women. Statistical analysis showed the significance level with p=0.000, p=000 and p=0.012 in age groups of 30-39, 40-49 and 50-59 of men, respectively. On the other hand, PPTO results of 40-49 age group of men showed a decrease PPTO measurement in comparison with 30-39 age group of men (p=0.012).

Table 7. Post-exercise pressure pain tolerance results in groups of women and men (kg).

Variable	Age Groups (yr)	Age Groups		
	30-39 (n=6)	40-49 (n=13)	50-59 (n=7)	
	$\bar{X}$±SS	$\bar{X}$±SS	$\bar{X}$±SS	p
Women	3.87±2.2	3.6±1.71	5.29±1.61	0.101
Men	13.05±4.42 **(*p=0.000)**	8.60±2.07 **(*p=0.000) (#p=0.006)**	8.92±1.55 **(*p=0.012)**	0.017

*p=000, difference from same age group of women, #p=0.006, difference from 30-39 age group of men. p column shows p values of Kruskal-Wallis test results among 3 age groups.

DISCUSSION

This study evaluated EIH phenomenon following a single bout of exercise in middle-aged recreationally active adults. The results of the present study demonstrated that one bout of voluntary exercise play resulted in an increase in PPT and PPTO values in all stratified age groups in both gender. Furthermore, post-exercise PPTO results were found to be higher in all age groups of men in comparison women at the same age. To our knowledge, this is the first study evaluating the alterations in pain threshold and tolerance following a voluntary exercise bout in healthy recreationally active middle-aged adults.

In the present study, a singles tennis match play was used as a voluntary exercise session which is one of the widely-used recreational exercise modality. Metabolic, neural, mechanical and thermal alterations during a tennis match play have been described in detail by (Kovacs, 2007; Mendez-Villanueva, Fernandez-Fernandez, & Bishop, 2007). The type of exercise performed in the present study was an intermittent exercise in nature, and RPE results showed that the intensity of the exercise bout was corresponded in a strenuous intensity as demonstrated in the previous literature (Novas 2003; Mendez-Villanueva, Fernandez-Fernandez, Bishop, Fernandez-Garcia & Terrados, 2007). It has been previously showed that the motivation for voluntary exercise in humans occurs in the multiple ways such as rewarding (Aidman & Woollard, 2003), or personality habits (Rhodes & Smith, 2006), and forced exercise and voluntary exercise exert different effects on the brain and behaviour (Leasure & Jones 2008). It has been also demonstrated that voluntary exercise induces several adaptive changes in central β-endorphin system (Hoffmann, Terenius & Thorén, 1990) which may be one of a contributing factor of EIH in the present study.

We used pressure stimulus to induce EIH in both genders of healthy middle-aged adults. Pressure stimulus is one of a widely used modality to demonstrate the alterations of pain perception in human studies (Naugle *et al.* 2012; Riley, Robinson, Wise, Myers & Fillingim, 1998). Other widely-used pain stimulus modalities are thermal, ischaemic or electrical stimuli (Rainville, Feine, Bushnell & Duncan, 1992; Naugle *et al.* (2012) demonstrated that EIH response does not correlate with the experimental pain modalities.

Our results showed that EIH occurs in both gender. However, male participants demonstrated the response in all age groups, while in women groups the statistically significant difference was found only in 40-49 years of age. Our results support the idea that EIH response shows a consistent pattern in men, however in women groups, a variable pattern becomes prominent among the groups of middle-age. It is conceivable to consider several factors such as hormonal, motivational, or neural mechanisms which could have an impact of the response in the decades of middle-age of women.

Literature findings suggested that women have lower pain threshold and tolerance to pressure pain stimulus in comparison with men without taking into consideration of age groups (Wandner, Scipio, Hirsh, Torres & Robinson, 2012; Racine, Tousignant-Laflamme, Kloda, Dion, Dupuis & Choinière, 2012a). In the literature review of 10 years of research, Racine, Tousignant-Laflamme, Kloda, Dion, Dupuis & Choinière, 2012b) demonstrated that hormonal or physiological factors are less responsible, cognitive or social factors partly explain the differences, and past individual history may be influential in female pain responses. We have previously demonstrated that simultaneously performed cognitive task may have influential effect on pain perception in athletes (Gündoğdu *et al.* 2014). In a recent study published by Brellenthin *et al.* (2017) demonstrated that there were no significant differences on EIH between women and men, however, psychosocial variables, such as the family environment and mood states, can affect the response. In the present study, however, we found an unaltered response at the baseline measurements between two genders at all age groups. On the other hand, we found an unaltered PPT response following exercise between two genders. The findings of the present study also clearly demonstrated that the PPTO results following the exercise of men are higher in comparison with all age groups of women, and are more consistent within the age groups. Our results are in accordance with the literature findings showing that women report lower pain tolerance (Racine *et al.* 2012a).

Several limitations should be mentioned in our study. Our participants were selected from the active adults playing recreational tennis for at least two years. Further studies should replicate by using a large number of groups of adults working on different kinds of sports, and different acute exercise protocols to clarify the mechanisms and possible consequences of hypoalgesic effect between short- or long-term specific adaptations of the exercise training. Secondly, we did not measure the stress response following acute exercise which may one of a confounding factor to affect our results of EIH. And finally, the number of participants of the present study might be insufficient to allow a generalization of our results to the community-based groups.

In conclusion, our results clearly showed that one bout of voluntary exercise apparently induced the exercise-induced hypoalgesic response in middle-aged recreationally active adults in both genders, and men have higher pain tolerance following exercise in comparison with women in all age groups.

PRACTICAL APPLICATION

The results of the present study showed that one session of voluntary exercise results in a hypoalgesic response in both genders, and increased pain tolerance in middle-aged men. Coaches and personal trainers should consider this condition especially at the initial phase of the recovery period following exercise to prevent possible tissue injuries due to the alterations of perception of pain.

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