**International Journal of Science Culture and Sport**
August 2014 : Special Issue 2
ISSN : 2148-1148
Doi : 10.14486/IJSCS187

# The effect of simultaneously performed cognitive task and physical exercise on pressure pain threshold and tolerance in athletes

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## Abstract

The aim of the study was to investigate the alterations of the pain threshold and tolerance after single, or dual task in athletes. Twenty male athletes and twenty non-athletic, recreationally active college students were participated in the study. Subjects were asked to perform Harvard step test (single task), and cognitive task was concurrent performance of an arithmetic task while performing Harvard step test. Pressure pain threshold (PPT) and pressure pain tolerance (PPTO) were assessed from muscle, tendon, bone and myofascial region from the dominant thigh by using a digital algometer. All measurements were repeated at rest, or following single and dual task. Results are presented as mean + standart deviation. Data were analyzed by using repeated measures of ANOVA test. A level of $p<0.05$ was accepted statistical significant. Athletes had higher PPT and PPTO measurements from muscle and myofascial region of thigh at rest. PPT and PPTO values were increased after single, or dual task in sedentary subjects, while athletic subjects had increased muscle and myofascial PPT and PPTO values after dual task. In conclusion, our results supports the notion that cognitive functions may interact the pain processing at rest, or following exercise in athletes.

**Key Words:** dual task, pain tolerance, cognitive task, athletes

## Introduction

Ahletes are frequently required to perform skilfully, under high temporal and cognitive pressure. In addition, athletes commonly be faced with situations during competition where they must perform multiple tasks simultaneously (Huang and Mercer 2001) yet still maintain skilled performance. In a wide range of sport branches, experts have been reported to exhibit more automated performance (Abernethy 1993). The high degree of automation evident in highly skilled performers results in greater resistance to skill decrement under dual-task conditions, and consequently more effective multi-task performance of concurrent tasks (Abernethy 1993). Dual-task procedures – procedures that require the contemporaneous performance of two tasks are commonly used to assess both the attentional demands of selected motor skills and the effects of a secondary task on the performance of these skills (Huang and Mercer 2001).

Pain perception in athletes is commonly believed to differ from pain perception in sedentary persons (Tesarz et al. 2012). It has been shown that athletes frequently continue to exercise in the face of severe injury. Several reports demonstrated that long-standing physical activity may alter pain perception and have often concluded that athletes possess higher pain thresholds and higher pain tolerance (Scott and, Gijsbers 1981, Spector et al. 1996).

The aim of the current study was to demonstrate the pressure pain threshold (PPT) and pressure pain tolerance (PPTO) both in sedentary and athletic persons, and determine whether the PPT or PPTO alter during single or dual task conditions athletes. We repeated the PPT and PPTO measurements from the the four different tissue regions of dominant thigh.

## Methods

### Participants

The study was conducted at Sport Science and Application Center of Akdeniz University. Twenty male athletes and twenty non-athletic, recreationally active college students were participated into this study. The study was approved by Akdeniz University Ethical Committee of Non-Interventional Clinical Research (09.04.2013 /84) and all experiments were conducted according to the latest revision of the declaration of Helsinki.

### Study design

The subjects were participated into three laboratory sessions, on 5 separate days. At the first visit, participants received instructions regarding the test procedure with a visual demonstration of the Harvard step test (single task) and the dual task. Thereafter, subjects performed one practice trial under single and dual-task conditions.

After having completed the practice trial, weight, height, PPT and PPTO measurements were completed from the subjects. At the second visit, participats were asked to perform a 5 minutes Harvard step test. Heart rate of the subjects were recorded three times after the test with one minute intervals. Fitness index was calculated from the recorded heart rate results and total stepping time. After completed the step test, PPT and PPTO values of dominant thigh were measured. At the third visit, participants were performed Harvard step test with an arithmetical subtracting test. Thereafter, PPT and PPTO measurements were repeated.

**Assessment**

Height was measured using an ultrasonic height measure (Soehnle-Waagen GmbH & Co. KG). Body weight, % fat, fat mass, free fat mass (FFM) and total body water (TBW) was measured with a Tanita Body Composition Analyzer (Model TBF-300 TANITA, Tokyo, Japan). Skinfold of dominant thigh was measured by using calliper.

**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 muscle, tendon, bone and myofascial regions of dominant thigh. Single measures of both threshold and tolerance were taken at 90-second intervals to prevent habituation (DeWall and Baumeister 2006, Orbach et al. 1997).

**Statistical analysis**

Results are presented as means + SD. Statistical significance was assessed by repeated measures of ANOVA followed by Tukey's post hoc test. A level of $p<0.05$ was accepted statistically significant.

**Results**

Table 1 summarizes the demographic caracteristics and body composition of two groups. Athletic group was younger, and has higher scores on body weight, fat mass and fitness index compared with the non-athletic group. The groups were not different in terms of height, % fat, FFM, TBW and skinfold measurement of dominant thigh. Athletic group was classified as having excellent levels, whereas sedentary group was classified as having moderate levels of fitness index.

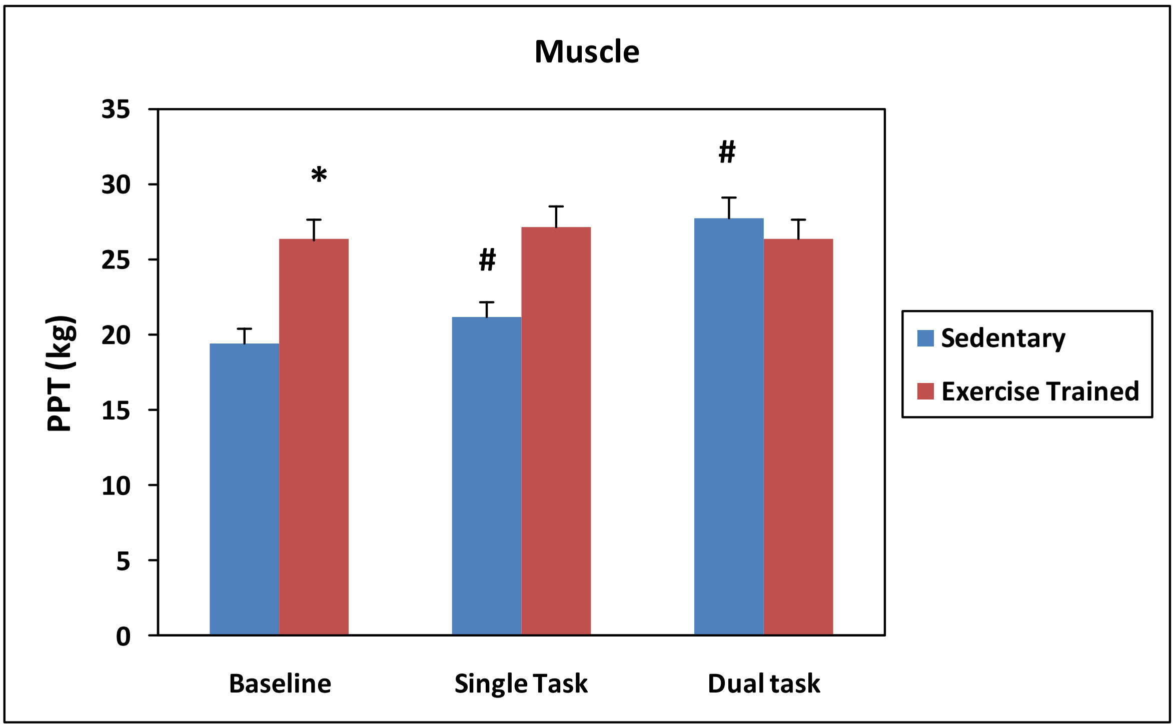
**Table 1.** Descriptive information and body composition for the study groups

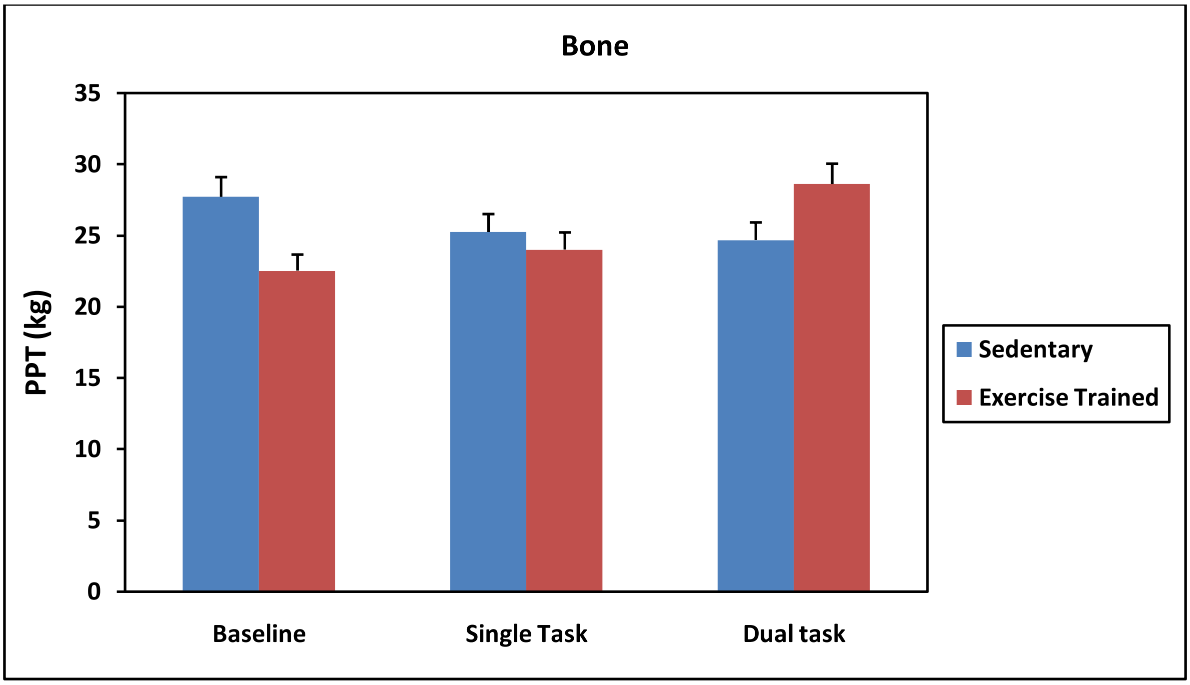
| | Sedentary | Athletes |
|---|---|---|
| Age (years) | 23,25 ± 1,39 | 20,00 ±1,18 *** |
| Body weight (kg) | 84,61 ± 12,91 | 73,45 ± 7,40 * |
| % Fat | 19,66 ±6,04 | 12,83 ± 18,25 |
| Fat mass (kg) | 17,10 ± 7,31 | 5,67 ± 2,12 *** |
| FFM (kg) | 67,51 ± 7,81 | 67,50 ± 5,37 |
| TBW (kg) | 49,44 ± 5,72 | 49,42 ± 3,91 |
| Skinfold (thigh) (cm) | 10,15 ± 1,41 | 9,09 ± 0,85 |
| Fitness index | 82,75 ± 6,92 | 100,7 ± 19,59 * |

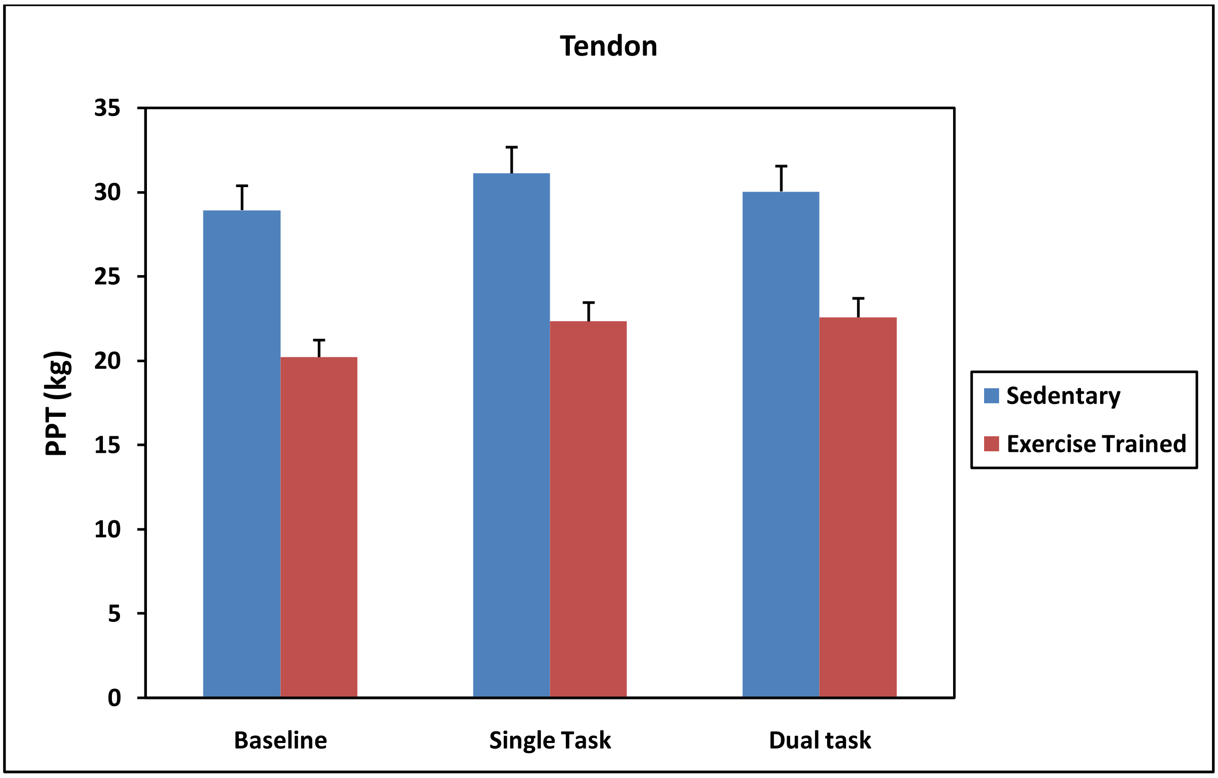
Values are expressed as mean + SD, n = 20 for each group. FFM: Fat free mass, TBW: Total body water, * $p < 0.05$, ***$p<0.001$, compared with the sedentary group

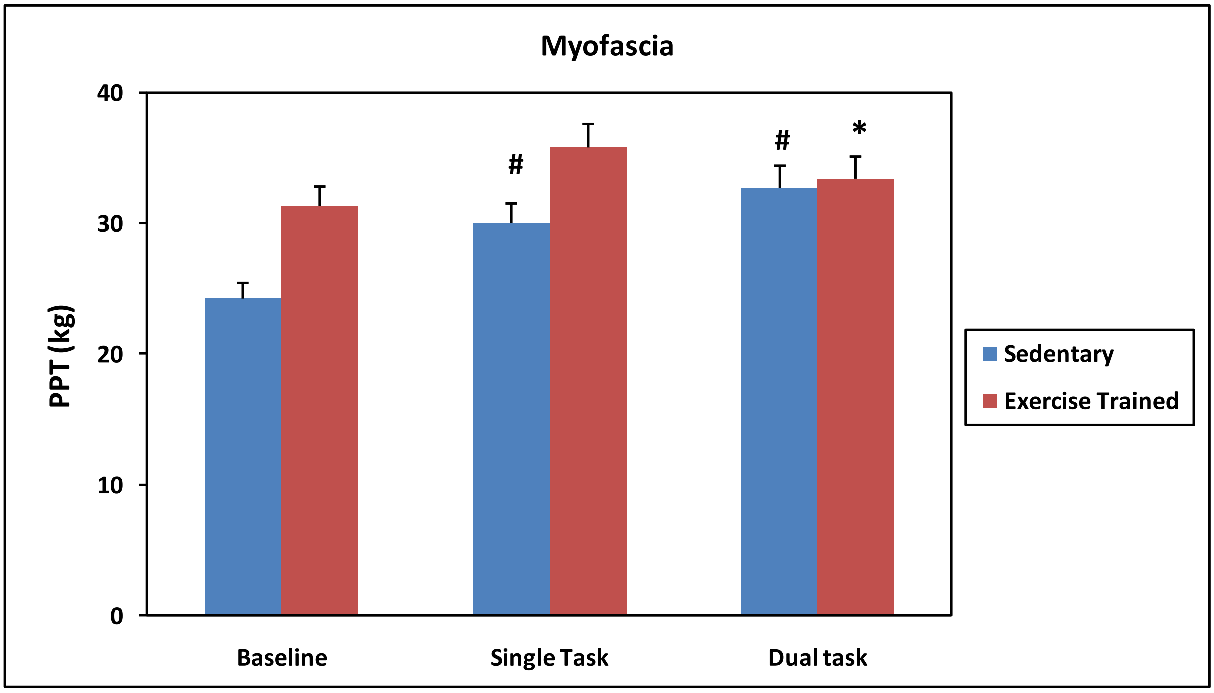
PPT and PPTO results obtained from four region of dominant thigh of two groups are presented in Figure 1 and 2. Higher muscle PPT values were obtained from athletic group in resting conditions. Although single and dual task resulted increased PPT and PPTO values in sedentary group, only dual task condition resulted increased muscle and myofascial PPTO measurement in athletic group (Figure 1 and 2).

**Figure 1**. Average pressure pain threshold (PPT) measurements from different regions of the dominant thigh (kg)



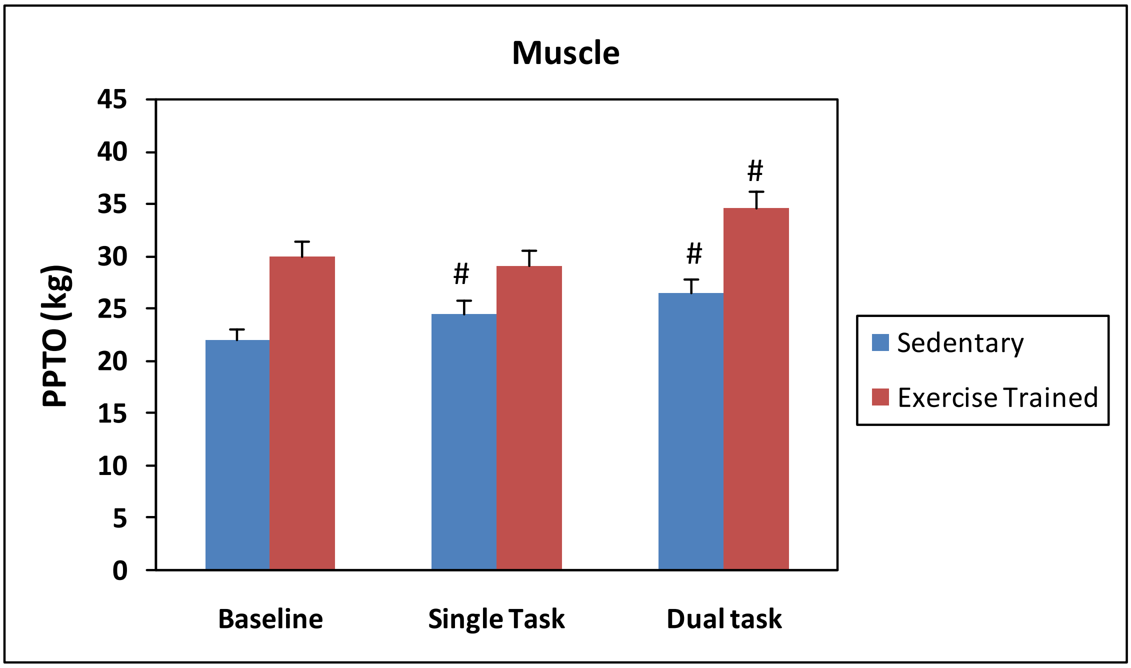



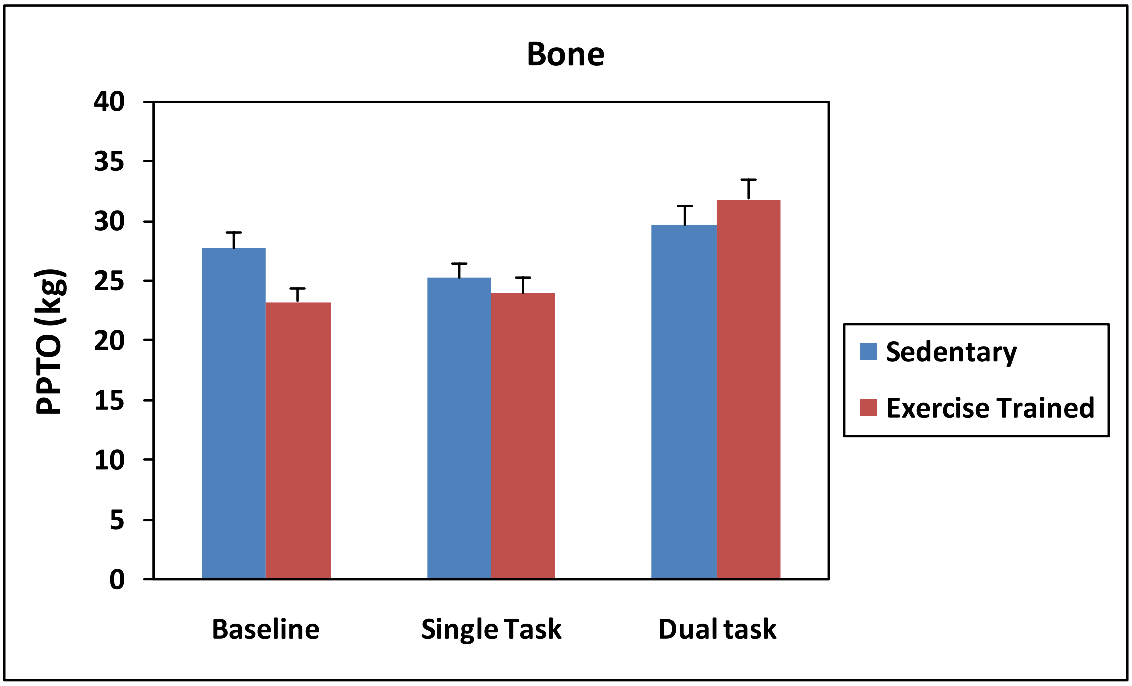


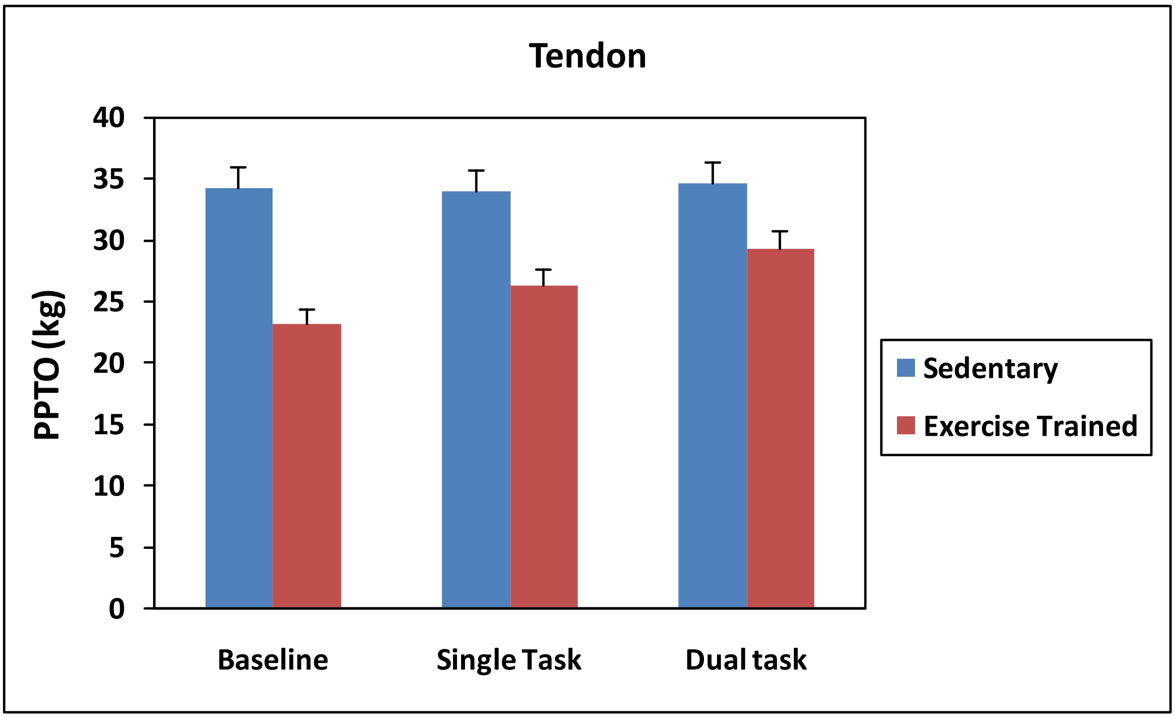



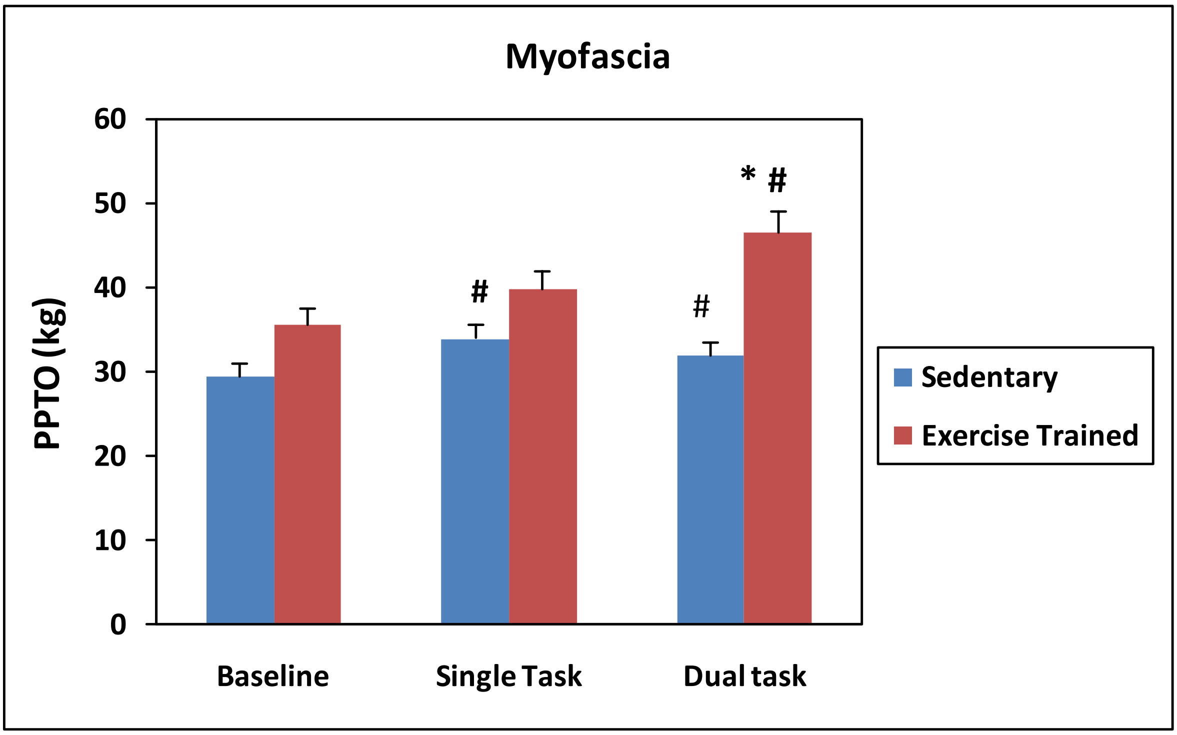

Values are expressed as mean + SD, n = 20 for each group. * $p < 0.05$ compared with the corresponding sedentary group measurement, # $p<0.001$ compared with the baseline score.

**Figure 2.** Average pressure pain tolerance (PPTO) measurements from different regions of the dominant thigh (kg)






Values are expressed as mean + SD, n = 20 for each group. *p < 0.05 compared with the corresponding sedentary group measurement, # p<0.001 compared with the baseline score.

**Discussion**

This study evaluated the pain threshold and pain tolerance differences in sedentary and athletic subjects after single and dual task conditions. To our knowledge, this is the first study evaluating the effects of simultaneous PPT and PPTO measurements after dual tasking conditions in athletes.

Fitness index of the participants in the present study clearly demonstrated that, athletes have higher fitness index compared with the sedentary subjects. Muscle and myofascial PPT and PPTO of sedentary people were found to be increased after single and dual task. This finding is supported by the previous reports demonstrated the EIH (exercise-induced hypoalgesia) (Koltyn 2000, Ozkaya 2014). In the present study, our results on athletes had higher PPT values in resting conditions supports the previous reports on pain perception is differ in athletic persons (Tesarz et al. 2012). Although we did not perform correlation analysis between fitness index and PPT and PPTO values, our results imply that there may be an interaction between pain perception and athletic training. The physiological mechanisms explaining EIH following exercise have not been elucidated in detail yet, but the available data suggest that one of the mechanism is the activation of diffuse nociceptive inhibitory mechanisms integreted by the brain (Kosek and Lundberg 2003, Tracey and Dunckley 2004). Exercise also activates endogenous analgesic mediators in laboratory animals (Ozkaya et al. 2014, Ozdemir et al. 2013), and also in healthy individuals (Droste et al. 1991).

Dual tasking conditions resulted an increment in muscle and myofascial PPTO of dominant thigh in athletes, and this finding suggested that, pain tolerance is strongly modulated by cognitive processing. Previous studies have demonstrated that physical exercise improves cognitive task in young (Barnes et al. 2003), and older people (Ozkaya et al. 2005, Çetin et al. 2010).

Several studies have demonstrated pain attenuation by a cognitive task, using psychophysical (Petrovic et al., 2000 and Terkelsen et al., 2004) and neouroimaging techniques (Bantick et al., 2002, Yamasaki et al., 2000). Hodes et al. (1990) found that simultaneous performance of a mental arithmetic task significantly reduced pain intensity during the first minute of exposure to cold pressor stimulation. These findings provide support for the notion that attention to a task distracts the individual from attending fully to the sensation of pain (Villemure and Bushnell, 2002). In the present study, both single task alone, and physical exercise with a cognitive task increased pain threshold and tolerance in muscle and myofascia regions of the dominant thigh of sedentary subjects. This finding suggests that it might be sensory stimulation per se, rather than the cognitive task associated with the stimulation, that is responsible for the attenuation of pain perception. Conceivably, such attenuation might be due to a gating or inhibitory mechanism triggered by the somatosensory stimulation during exercise loading. As for the gating mechanism, there is evidence for auditory-induced gating of neural activity in the brainstem periaquaductal grey (PAG) (Bajo and Moore, 2005 and Nonaka et al., 1997). Since gating of pain also takes place in the PAG (Fields and Basbaum, 1999 and Valet et al., 2004), there might be an interaction by the auditory and pain processing at this level. Another possibility is that the interaction between the two sensory modalities takes place at higher levels, especially the anterior cingulate cortex (ACC) (Seminowicz et al., 2004).

Several limitations of the present study should be mentioned. The lack of the differences of baseline PPTO between exercise trained group and sedentary group in our study could be due to the great variations of the pain tolerance measurements of the subjects which could be overcome by increasing the number of the participants. Also baseline differences in cognitive status between two groups which we did not measure in the present study may have influenced our results. Further studies should be conduct to clarify the possible mechanisms of altered pain sensitivity during different aspects of cognitive tasks such as hormonal factors, increased production of several neurotrophic factors, or individual differences in acute exercise, or conditions of exercise training.

In conclusion, our data suggest a strong relationship between pain threshold, and tolerance after single and dual tasking conditions in athletes.

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