Ankle brace does not influence strenght and functional balance of ankle muscles over an exercise at the intensity of basketball game

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Abstract

The purpose of this study was to analyze the effects of an exercise at the intensity of basketball game and use of ankle brace on isokinetic peak torque (PT) of ankle's stabilizing muscles and evertor eccentric/invertor concentric functional ratio. Seventeen male basketball players, performed a test at the intensity of basketball game, under two conditions: with and without ankle brace. The test consisted of succession typical physical efforts of basketball game, distributed equally in four periods of 10 min each. Muscle strength and functional ratio were assessed at 120 deg.s^{-1}, before (Pre), at half time (Half time) and after exercise (Pos). Isokinetic data were analyzed using repeated-measures ANOVA (2x3) ($p < 0.05$). In both conditions concentric and eccentric invertor PT, respectively, decreased ($p < 0.05$) when compared: Pre vs. Half time (-10.1% and -8.4%); Pre vs. Pos (-17.7% and -16.4%); Half time vs. Pos (-8.4% and -8.9%). Differently, concentric and eccentric evertor PT, respectively, reduced ($p < 0.05$) only when compared: Pre vs. Half time (-14.4% and -12.0); Pre vs. Pos (-15.1% and -15.2%). There was no significant difference between conditions for PT and functional ratio ($p > 0.05$). These findings show that fatigue induced by exercise at the intensity of basketball game decreased PT with no change in the muscle balance over the ankle. Furthermore, the use of brace did not affect the ankle muscles' ability to generate dynamic torque nor ankle's functional balance. These results, suggest that athletes might have increased risk of ankle injury in the basketball game due to fatigue and the use of ankle brace would not be detrimental to ankle muscle strength during a basketball game.

KEYWORDS: Muscle strength; Ankle sprains; Basketball.

Introduction

Ankle injuries are the most common in sports. About 80% of these injuries ocorrus due to ankle ligamentous sprain[1] with the peak incidence between fifteen and nineteen years of age[2]. Sports that involve jump, running and sudden changes in direction have high risk of ankle injuries. Among these sports, basketball deserves special attention because about 41% of ankle sprains occur during basketball games[2]. Thus, the incidence of ankle sprain in basketball players (3.2 per 1000 athlete exposures)[3] is more than twice as common as any other injury[4].

Ankle injuries have multifactorial causes with several risk factors interacting at a given time[5]. However, studies report that athletes participating for longer periods of time in basketball game are more likely to be injured. The high frequency of injuries in games occurs because maximum effort is expended during games, and thus the athlete is more vulnerable to injury[6].

There is also evidence that fatigue is a potential mechanism for ankle injury incidence during intense and prolonged exercise, as in a basketball game[6-7]. Fatigue has been assumed to be capable of promoting declining strength of the ankle's stabilizing muscles, alter neuromuscular control and compromise the ability to determine the sensitivity of joint positioning that are directly associated with ability to dynamically stabilize the ankle joint during sports activities[8-11].

Currently researchers have used a variety of protocols to investigate the effects of fatigue on ankle's stabilizing muscles[8, 10-11] but these were either not basketball specific. Thus, extrapolations these findings for basketball practice should be made with caution.

With respect to ankle injury prevention, the use of ankle brace have been suggested[12-14]. Recent study showed that use of ankle bracing decreased the incidence of ankle injury during the basketball game[12-13]. Thus, when an athlete is using ankle brace the stability of this joint would be enhanced because the ankle inversion range of motion is diminished. In addition, the use of ankle brace reduce the acceleration of inversion and eversion movements[15-16].

In this sense, several studies show positive acute effects of the use of ankle bracing. For exemple: Faraji et al.[17] observed that the braces may enhance ligament mechanoreceptor function and cause the stimulation of a greater number of peroneal motoneurons and then improved dynamic postural stability; Lohrer et al.[18] reported a potent facilitatory effect on EMG amplitude during inversion injury simulation; Cordova et al.[19] found that ankle bracing reduced the average EMG activity of the peroneus longus, possibly reducing the strain or load that is placed on the muscle that dynamically limits forced inversion of the foot; and Hartsell and Spaulding[15] identified at low isokinetic velocity that the ankles with braces produced higher concentric evertor peak torque than the unbraced ankles.

On the other hand, researchers have reported contradictory results about the effects of the use of ankle brace when the participant is fatigued. Forbes et al.[20] found that the use of ankle brace loses the initial level of resistance to motion during soccer-specific protocol, while Shaw et al.[21] observed improvement of postural dynamic stability in the anteriorposterior direction during a landing task using ankle brace in fatigued condition. Additionally, Kelly et al.[22] showed that use of foot orthoses may alters neuromuscular control during a submaximal 1-h treadmill run and partly protects from the resulting fatigue-induced reductions in rapid force development of the plantar flexors.

Nevertheless, to the authors' knowledge no study has investigated the effects caused by the fatigue and use of ankle brace on muscular capacity, particularly, ankle invertor and evertor torque generation, during basketball game. Therefore, there are limited biomechanical data from which a relationship between ankle brace vs. fatigue vs. basketball game may be inferred.

Thus, due to high complexity in analyzing the musculoskeletal demands in real basketball game the present study aimed to analyze the effects of a exercise at intensity of basketball game and use of ankle brace on isokinetic peak torque (PT) of ankle's stabilizing muscles and evertor eccentric/invertor concentric functional ratio. Our initial hypotheses are: the strength of the ankle's stabilizing muscles is impaired over the activity differentially among invertor and evertor muscles, changing ankle's functional balance; and the use of ankle brace reduces the decline of torque of ankle's stabilizing muscles over the exercise protocol.

Method

Subjects

Seventeen male recreational basketball players, with five years or more of experience in basketball practice were considered for this study. All were actively participating in basketball training and games at least three a week. Participants had in average 17.7 ± 1.4 yrs, height of 181.9 ± 9.0 cm, body mass of 79.1 ± 13.9 kg, percentage of fat of 12.5 ± 6.8% and score in Cumberland Ankle Instability Tool questionnaire[23] of 27.4 ± 2.4 points for the dominant ankle and 26.7 ± 2.4 points for non dominant ankle. All the participants included in this investigation were injury free during and in the six months preceding testing and did not have mechanical or functional ankle instability. All participants signed a consent form in accordance with departmental and university ethical procedures.

Procedures

The volunteers visited the laboratory on three separate occasions within 48-72 hours. On the first day of data collection, mechanical ankle stability was evaluated using the ankle anterior drawer test and the talar tilt test which were performed by an experienced physical therapist[24]. Participants with positive results in these tests were not included. Functional ankle stability was evaluated using the Cumberland Ankle Instability Tool (CAIT) questionnaire[23] and were included only the participants with scores higher than 24 on a scale of 0-30 in CAIT. After that, lower limb dominance was identified using three different tasks: ball-kick test, step-up test, and balance recovery test. Three trials of each test were conducted. The limb that was used for most trails was identified as the dominant limb for that specific functional test. The limb used as the dominant limb in most specific functional tests was defined as the functional dominant limb[25]. Then, the participants were familiarized with the exercise protocol and isokinetic contractions[26].

On the second and third visits, participants warmed up on a cycle ergometer (Cefise™, Nova Odessa, Brazil) for five minutes at 75 W and 70-80 rpm. Then, the isokinetic assessment and the exercise protocol were performed. Exercise protocol was performed under two different conditions: with ankle brace (Braced) and without ankle brace (UnBraced). The order of the conditions was randomized and the braces were wore bilaterally. The brace used was a lace-up ankle brace (Hourse JumpTM, Franca, Brazil). The lace-up brace was selected because it is commonly used by basketball players and reduce acute ankle injuries in basketball[13-14]. All participants had prior experience with the bracing tested by at least 1 week in basketball training before to the day of the assessments to allow the feet and body to adjust to any biomechanical changes induced by the devices[22].

Strength assessment

Strength measurements were taken in three different times, during the breaks of exercise protocol: before the test (Pre), at half time after second period of exercise (Half time), and immediately after (about 30 s) fourth period of exercise (Pos). The strength assessments, in both conditions, were carried out without use of brace in the ankle tested, due to the mechanical restrictions caused by it.

Participants were placed on the seat of the isokinetic dynamometer (Biodex™, New York, United States) and the movement of the upper body was limited by two cross-over shoulder harnesses and an abdomen belt. The inclination of the seat was kept at 70° while the knee was kept at 110° of extension (180 = full extension) and the leg was placed parallel to the floor. The ankle joint was kept at 10° of plantar flexion[25, 27], the subtalar joint was placed in neutral position[28], and the dynamometer was aligned to approximate the axis of rotation of the tested ankle joint according to the manufacturer's manual.

Participants performed five concentric and eccentric maximum isokinetic contractions of inversion and eversion of the ankle at 120 deg.s^{-1}, which correspond to approximately 50% of the average velocity reached during an inversion sprain of the ankle[29]. A rest of two minutes was given between the inversion and eversion strength assessment[15]. These tests were performed in random order, using only dominant lower limb. All participants received positive verbal encouragement during testing.

Exercise protocol

The exercise protocol was developed to provide fatiguing exercise estimated to be equivalent to playing a game of basketball. Exercise protocol consisted of different exercise intensities that are observed during basketball game (e.g. walking, jogging, running, sprinting, vertical jump, side shuffle and changes of direction), following the procedure employed by Castro et al.[7] and in accordance with the observations of Matthew and Delextrat[30], Ben Abdelkrim et al.[31] and Scanlan et al.[32] during basketball game. These physical efforts were performed on the ground and on the treadmill.

The test started on a 3 by 4 meter rectangle area marked on the ground, on which specific movements were performed, including forward sprint, side shuffle and changes of direction. After a sound feedback given by a photocells system (Cefise™, Nova Odessa, Brazil), used to record the speed, the participant started the test with a forward sprint of three meters (onto side 1 in FIGURE 1), followed by a change of direction and then a forward sprint of four meters (onto side 2 in FIGURE 1). Then, (on getting to the end of side 2 in FIGURE 1) they proceeded with the side shuffle of five meters (on the diagonal 3, FIGURE 1), moving towards the initial position. The participants were guided to make all movements using their maximum speed. At the initial position, they had a rest of three seconds, and this procedure was performed consecutively during 40 s, and then paused for 30 s.

Immediately after the 30 s rest, they ran on the treadmill (Inbramed®, Gravataí, Brazil), in different speed (3.6-19 km.h^{-1}) and typical distances of a basketball game. Thus, the protocol was composed by: running at 15 km.h^{-1} for 20 s; vertical jump on the ground; rest for 20 s; jogging at 11 km.h^{-1} for 10 s; sprinting at 19 km.h^{-1} for 10 s; rest for 20 s; walking at 3.6 km.h^{-1} for 10 s; and jogging at 11 km.h^{-1} for 10 s; vertical jump on the ground and then a rest for 20 s.

The procedures described were performed in six consecutive trials, giving a total of 10 min of exercise. For the representation of the whole game, four periods of 10 min were performed. A rest of 2 min. was given between the first and second period, and between the third and fourth periods. The rest between the second and third periods was set at 15 min.[7,33]. The participants remained seated and stationary during rest periods.

The heart rate was measured by a heart rate monitor (PolarTM, Kempele, Finland) at the end of each condition performed on the treadmill or on the ground, as a parameter indicator of intensity of exercise between the two conditions tested.

Adapted from CASTRO et al.[7] .

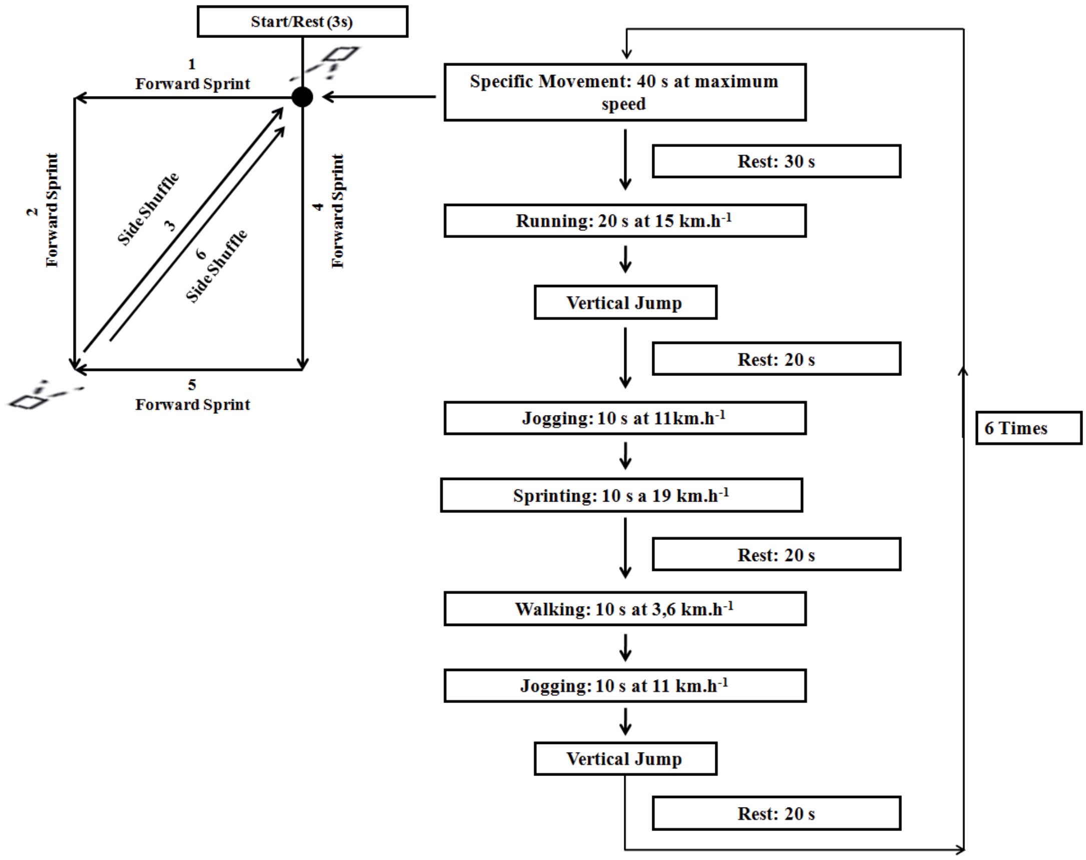


FIGURE 1 - Exercise protocol.

Data analyzes

The torque signals were filtered by using low-pass digital filter (recursive Butterworth fourth-order zero-lag) with a cutoff frequency of 8 Hz[34]. Among the five trials, the one that produced the highest peak torque (PT) was considered for further analysis. The following parameters were obtained: concentric and eccentric evertor PT, concentric and eccentric invertor PT and functional ratio of the dominant lower limb. The functional ratio representative for ankle inversion was determined as the eccentric evertor PT divided by concentric and eccentric invertor PT[35-36].

Statistical analysis

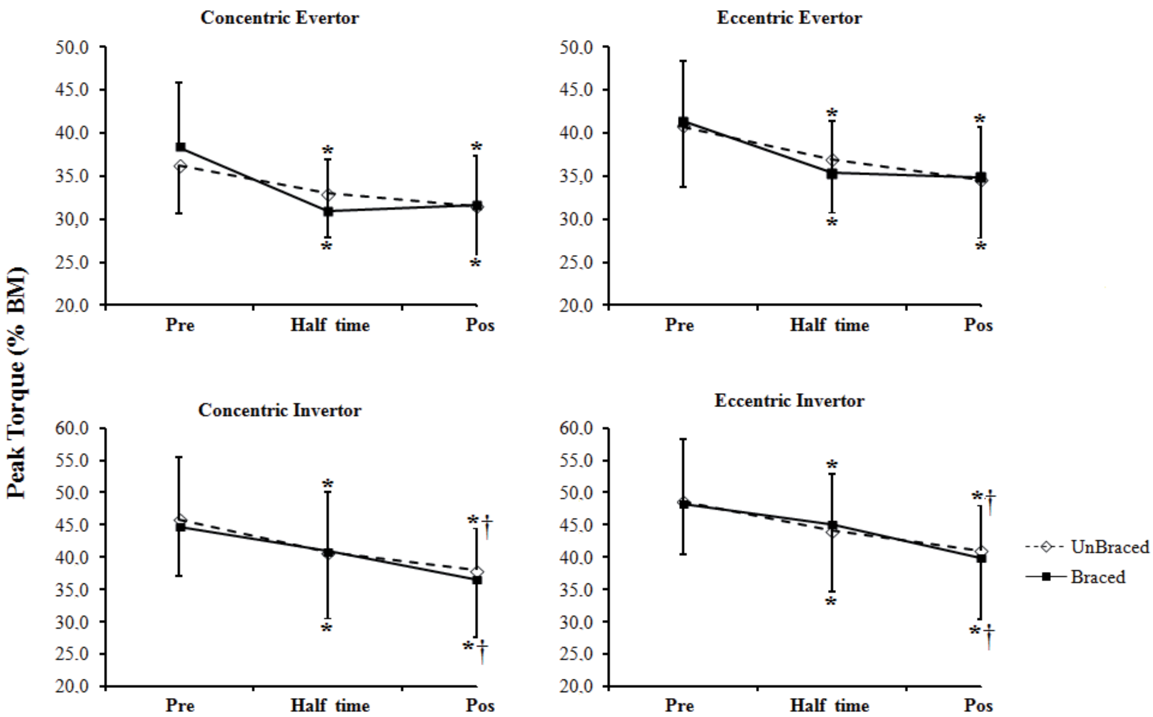
PASW 18.0 (SPSS Inc., Chicago, United States) was used for all statistical analyses. The distribution of all dependent variables was examined by Shapiro-Wilk test. Paired t-test was applied to compare the mean heart rate between Braced and UnBraced conditions. Isokinetic data were analyzed by using Repeated Measures ANOVAs 2x3 [condition (Braced and UnBraced) vs. time (Pre, Half time and Pos)]. Assumptions of sphericity were evaluated using Mauchly's test. Where sphericity was violated ($p < 0.05$), the Greenhouse–Geisser correction factor was applied. In the case of significant main effects, Sidak's post hoc with adjusted p-values for multiple statistical tests was performed to decrease the risk of Type I error and to determine where significant differences occurred. Significance level adopted was set at $p < 0.05$. Effect size (ES) was calculated using G*Power 3.1.7 software (Franz Faul, Universitat Kiel, Germany) according to the recommendations of Beck[37].

Results

There were no significant ($P > 0.05$) main effects of condition for PT and functional ratio (FIGURE 2 and FIGURE 3). Also, it was not found significant differences between conditions for the average of the heart rate (Braced: 161.6 ± 8.2 beats.min^{-1}; UnBraced: 161.2 ± 8.6 beats.min^{-1}) during the exercise protocol ($p = 0.816$, ES = 0.05).

However, a within-subjects main effect of time for PT: eccentric evertor ($F_{2,32} = 28.2$, $p < 0.001$, Power = 0.99); concentric evertor ($F_{2,32} = 22.0$, $p < 0.001$, Power = 0.99); eccentric invertor ($F_{2,32} = 36.5$, $p < 0.001$, Power = 0.99); and concentric invertor ($F_{2,32} = 37.4$, $p < 0.001$, Power = 0.99) was found (FIGURE 2). There was not significant main effect of time for functional ratio ($p = 0.80$) (FIGURE 3).

In both conditions the concentric and eccentric invertor PT, respectively, decreased when were compared measures: Pre vs. Half time (-10.1%, $p = 0.001$, ES = 0.46; -8.4%, $p = 0.003$, ES = 0.41); Pre vs. Pos (-17.7%, $p < 0.001$, ES = 0.89; -16.4%, $p < 0.001$, ES = 0.87); and Half time vs. Pos (-8.4%, $p = 0.01$, ES = 0.37; -8.9%, $p = 0.001$, ES = 0.42). Differently, the concentric and eccentric evertor PT, respectively, reduced only when compared measures: Pre vs. Half time (-14.4%, $p < 0.001$, ES = 0.96 =; -12.0%, $p < 0.003$, ES = 0.89); Pre vs. Pos (-15.1%, $p < 0.001$, ES = 0.99; -15.2%, $p < 0.001$, ES = 1.10) (FIGURE 2).



Percentage of body mass (%BM).
*, †: Significant difference from Pre and Haf time, respectively ($p < 0.05$).

FIGURE 2 - Mean (±SD) peak torque before (Pre), at half time (Half time) and after (Pos) simulated basketball game test.

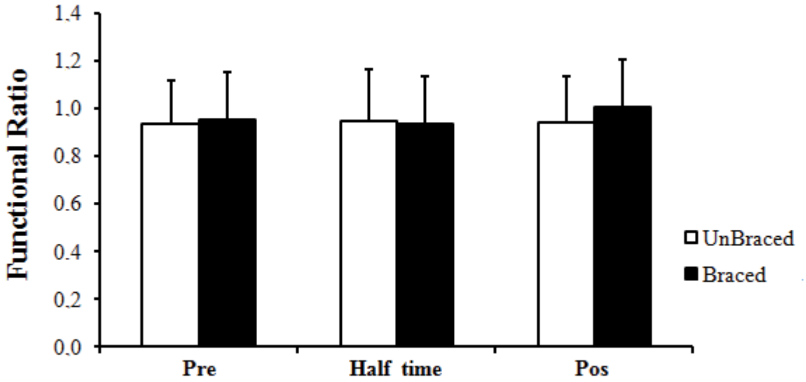


FIGURE 3 - Mean (±SD) functional ratio before (Pre), at half time (Half time) and after (Pos) simulated basketball game test.

Discussion

This study aimed to investigate the effects of a exercise at intensity of basketball game and use of ankle brace on strength and functional ratio of the ankle's stabilizing muscles. The most novel aspect of this study is that it demonstrated that strength of ankle's stabilizing muscles decreased over exercise at the same intensity of basketball game without to change the ankle evertor eccentric/invertor concentric functional ratio. However, no significant effect of the use of ankle brace on ankle invertor and evertor strength was found. With respect to our results, it agrees with our hypothesis that the strength of the ankle stabilizing muscles declines over the exercise; On the other hand, the hypothesis that the use of ankle brace prevents the decline of ankle stabilizing muscles strength during simulated basketball game was refuted. Moreover, it is important to note that the heart rate data indicate that there were no significant physiological differences between the levels of effort when using and not using the ankle braces, suggesting that the conditions were indeed comparable.

These findings demonstrates that over the exercise protocol the strength of ankle invertor and evertor muscles is reduced, which is in agreement with Gutierrez et al.[8], Sandrey and Kent[11] and Wright and Arnold[9] studies. These authors found a similar reduction (12-15%) in the capacity of ankle evertor and invertor muscles to generate torque after a protocol of fatigue performed using isokinetic contractions[8,11] and reduction of 30% using isometric contractions[9]. We did find strength deficits of 8-18% during eccentric and concentric actions with the fatigue promoted by an exercise at intensity of basketball game. Although there are similarities with these studies, the present study has greater ecological validity as the data bear closer resemblance to that of basketball game.

Nevertheless, it is important to highlight that isokinetic assessments do not represent completely ankle "natural" movements and the tested velocities are often lower than those achieved during functional activities. Even so, the information obtained from isokinetic muscle testing (PT and functional ratio) is still of value to the clinician when investigating the muscle strength of a given, isolated muscle group[36]. Strength deficits of 8-33% and 6-41%[27, 35] in strength of ankle evertor and invertor muscles have been strongly associated to joint instability and the risk of ankle sprain injuries[8-11].

Although the distribution of the injuries occurrence among the quarters of the game are little known[38], athletes who participate for more time in the game are more likely to be injured[6]. Thus, as was observed by findings in the present study, the reduction demonstrated in strength of the ankle stabilizing muscles may be one reason for the increased risk of the ankle injuries at the second half of the game.

This results emphasises the importance of endurance training in ankle rehabilitation to avoid fatigue at the end of each half of game. It also allows us to suggest preventive training programmes for when the players are more fatigued, for exemple, at the end of training sessions[39]. However, further research are required to determine whether these interventions can reduce the risk of injury and how these injuries are distributed throughout game.

According to this, studies have been suggested that when the strength of the ankle invertor and evertor muscles is reduced due fatiguing efforts, the capacity of these muscles to generate torque fast and high magnitude to prevent injury is reduced[8, 9,11,27], It is reported that fatigue of the evertor muscles is the dominant cause of lack of ankle stability[40]. The impairments in evertor strength may reduce these muscles' ability to dynamically control inversion and thus predispose the ankle to an inversion sprain[8, 27, 40-41].

On the other hand, we did not find significant difference for the ankle functional ratio. Studies showed that the functional ratio represent a more realistic approximation of muscle activities observed in activities of daily living or as sports motor tasks. This ratio has important clinical appliance to prevent ankle sprain injuries in athletes. It describes the resistive capacity of antagonist muscles (eccentric strength) in relation to the concentric motor action of agonistic muscles[35-36].

Thus, reduction of 25% to 50% on this ratio may be considered an indicator of ankle instability and increased risk of ankle sprain injuries[35-36]. However, the induced fatigue caused by exercise at intensity of basketball game did not change the dynamic strength balance on ankle (as evidenced by eccentric evertor and invertor strength impairments).

These findings may have functional significance, is possible to speculate about the neural activity pattern which may regulate the loss of strength in evertor and invertor muscles similarly for the continuity of the normal function of the ankle joint with the fatigue[35]. Thus, maintaining constant the functional ratio. Unfortunately, our study does not clarify this issue and future research are suggested to analyze neuromuscular parameters ankle in long duration activities, such as in a basketball game.

Considering the wearing of bracing, we observed a lack of the effect of the use the brace to prevent the decline in torque production of ankle evertor and inverter muscles over the exercise protocol. In this sense, others found in literature showed that the use of ankle bracing can reduce the risk of ankle injuries without impair the torque production of ankle invertor and evertor muscles during isokinetic assessments[15,42], isometric assessment[43,44] and sudden ankle inversion[45]. This indicates that the use of ankle brace does not differentially affect strength following extended exercise, as the basketball game.

With respect to these results, we suggest two possible explanations for the absence of the effect of ankle brace. Firstly the effects of the use of ankle brace is often attributed to the brace's structural characteristics that contributes to provide passive resistance to the ankle inversion movement when the evertor muscles were not activated[44-45]. And secondarily, although studies show neuromuscular and proprioceptive effects with use of ankle bracing[17-19,21], it is possible that changes in these parameters are unable to significantly change the torque production. For example, Kelly et al.[22] observed reduced electromyographic activation for gastrocnemius medialis muscle during 1-h treadmill run with orthoses and smaller fatigue-induced decrements in the rate of torque development after running with foot orthoses. However, these changes were too small to alter PT of ankle plantar flexors.

Finally, it is important to note some limitations of the present study. This study refer to the strength responses over an exercise at intensity of basketball game in only male under-18-year-old basketball players. Thus, extrapolations of our findings need to be made with caution. Besides, the present study only investigated the effect of ankle brace on strength responses. Thus, we cannot suggest if the use of ankle brace would contributes mechanical stability of ankle joint during the exercise (such as reduction of ankle invertor range of motion). Finally, although limitations are evident on reproducing real conditions in the laboratory under controlled conditions, the exercise protocol was able to simulate duration, typical efforts and heart hate characteristics of a basketball game[30-32]. Future studies may be conducted to investigate the effect of ankle brace on ankle neuromuscular parameters during sports activities of long duration.

In conclusion, our findings demonstrated that the fatigue induced by exercise at intensity of basketball game decreased the strength of ankle's stabilizing muscles, without change functional balance over the ankle. These findings indicate that during basketball game muscles around the ankle joint are fatigued, witch may to increase risk of injury. Thus, preventive programs focusing on strengthening and endurance of the muscles around the ankle in basketball players should be encouraged. Furthermore, according to our findings, use of ankle brace did not prevent the decline of ankle invertor and evertor strength over an exercise at intensity of basketball game and did not affect de ankle muscles' ability to generate dynamic torque nor ankle's functional balance. These results suggest that the brace selected in this study would not be detrimental to ankle muscle strength during a basketball game.

Resumo

Órtese de tornozelo não influencia a força e o equilíbrio funcional dos músculos do tornozelo durante exercício em intensidade do jogo de basquetebol

O objetivo do presente estudo foi analisar o efeito de um exercício em intensidade do jogo de basquetebol e uso de órtese de tornozelo sobre o pico de torque (PT) isocinético dos músculos estabilizadores do tornozelo e a razão funcional eversor excêntrico/inversor concêntrico. Dezessete homens jogadores de basquetebol realizaram um teste em intensidade do jogo de basquetebol, sob duas condições: com e sem órtese no tornozelo. O teste consistiu em uma sucessão de esforços físicos típicos do jogo de basquetebol, distribuídos igualmente em quatro períodos de 10 min cada. Força muscular e a razão funcional foram avaliadas a 120 graus.s^{-1}, previante (Pré), no intervalo do Meio (Intervalo do Meio) e após (Pós) o exercício. Os dados isocinéticos foram analisados usando ANOVA de medidas repetidas (2x3) ($P < 0,05$). Em ambas as condições o PT inversor concêntrico e excêntrico, respectivamente, diminuiu ($P < 0,05$) quando comparado: Pré vs. Intervalo do Meio (-10.1% e -8.4%); Pré vs. Pós (-17.7% e -16.4%); e Intervalo do Meio vs. Pós (-8.4% and -8.9%). Entretanto, o PT eversor concêntrico e excêntrico, respectivamente, reduziu ($P < 0,05$) somente quando comparado: Pré vs. Intervalo do Meio (-14.4% e -12.0); Pré vs. Pós (-15.1% e -15.2%). Não houve diferença significativa entre as condições para o PT e razão funcional ($P > 0,05$). Estes resultados mostram que a fadiga induzida pelo exercício em intensidade do jogo de basquetebol reduziu o PT sem alterar o equilíbrio muscular sobre o tornozelo. Além disso, o uso da órtese de tornozelo não afetou a capacidade muscular em gerar torque dinâmico nem o equilíbrio funcional do tornozelo. Estes resultados sugerem que atletas podem ter um aumentado risco de lesão no tornozelo no jogo de basquetebol devido à fadiga e que o uso da órtese de tornozelo não será prejudicial para a força muscular do tornozelo durante o jogo de basquetebol.

Palavras-chave: Força Muscular; Entorse de Tornozelo; Basquetebol.

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