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ORIGINAL

JUMP PERFORMANCE AFTER DIFFERENT FRIENDLY MATCHES PLAYED ON CONSECUTIVE DAYS

RENDIMIENTO DEL SALTO TRAS VARIOS PARTIDOS DE FÚTBOL DISPUTADOS EN DÍAS CONSECUTIVOS

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ABSTRACT

The aims of the study were to determine the change in countermovement jump (CMJ) after three friendly matches played on consecutive days, and to evaluate if there is a significant correlation between the changes observed in CMJ height with respect to the minutes played and the rate of perceived exertion (RPE) values. The CMJ height of 22 young male soccer players (age: 16.6±0.8 years) was determined in 5 occasions: pre-trip, pre-game 1, pre-game 2, pre-game 3, and post-trip. The results showed a reduction in jump height when compared to the pre-trip ($P<0,001$; effect size ≥ 1.47), while the change in jump height was

not significantly correlated with the minutes played ($r=-0.02$; $P=0.464$) nor with the RPE values ($r=0.15$; $P=0.249$). The succession of football matches promotes a decrease in jump height that is not related to the minutes played nor to the RPE values.

KEY WORDS: fatigue, CMJ, RPE, soccer.

RESUMEN

Los objetivos del estudio fueron determinar el cambio en la altura alcanzada en el salto con contramovimiento (CMJ) tras tres partidos amistosos jugados en días consecutivos, y evaluar si existe una asociación significativa entre los cambios en la altura del CMJ respecto a los minutos disputados y los valores de percepción subjetiva del esfuerzo (RPE). La altura de salto de 22 jóvenes futbolistas varones (edad: $16,6\pm 0,8$ años) fue determinada en 5 ocasiones: Pre-viaje, Pre-partido 1, Pre-partido 2, Pre-partido 3, y Post-viaje. Los resultados mostraron una reducción de la altura de salto respecto al pre-viaje ($P<0,001$; tamaño de efecto ≥ 1.47), mientras que el cambio en la altura de salto no estuvo significativamente correlacionado con los minutos disputados ($r=-0.02$; $P=0.464$) ni con la RPE ($r=0.15$; $P=0.249$). La sucesión de partidos de fútbol provoca una disminución en la altura de salto que no está relacionada con los minutos disputados ni la RPE.

PALABRAS CLAVE: fatiga, CMJ, RPE, fútbol.

INTRODUCTION

Soccer is an acyclic sport of intermittent nature in which performance is highly influenced by actions that are performed at high intensity (Faude, Koch, & Meyer, 2012). During matches, players perform a number of high-intensity actions such as sprints, accelerations, decelerations, changes of direction, jumps, tackles and kicking (De Hoyo et al., 2016, Marqués-Jiménez, Calleja-González, Arratibel, Delextrat, & Terrados, 2017). The succession of these actions induces alterations in the musculoskeletal, nervous, metabolic and immune systems (De Hoyo et al., 2016) leading to the fatigue of soccer players (Brownstein et al., 2017; Thomas, Dent, Howatson, & Goodall, 2017). It is known that the fatigue induced by soccer matches can decrease physical performance during several days after the competition (Ispirlidis et al., 2008, Roe et al., 2017). The current high exigence of the competitive, where elite soccer players can play two or three matches in the same week (Marqués-Jiménez et al., 2017), and long trips performed in uncomfortable conditions, are situations that can also affect to the performance of soccer players (Fowler, Duffield, & Vaile, 2015). However, the fatigue induced by matches played on consecutive days in young soccer players, who frequently play this type of competitive tournaments, has been little studied.

Sports scientists and fitness coaches often perform tests to assess the neuromuscular status of athletes. The countermovement jump (CMJ) has been one of the most used tests to determine the neuromuscular performance of the lower limbs in both individual and team sports (Claudino et al., 2017). In soccer, the high physical demands produce neuromuscular fatigue during certain phases of the match as well as in the final phase of each half time (Silva et al., 2017), producing a decrease in the jump height immediately after the match (Marquis- Jiménez et al., 2017), 24 hours (Roe et al., 2017), 48 hours (Watkins et al., 2017), 72 hours (Marqués-Jiménez et al., 2017; Roe et al., 2017 Silva et al., 2017) and even 96 hours post-match (Thomas et al., 2017). However, some investigations have not found a significant correlation between exercise-induced neuromuscular fatigue and the decrease in CMJ height (Krustrup, Zebis, Jensen, & Mohr, 2010; Thorlund, Aagaard, & Madsen, 2009). Therefore, it could be interesting to analyze whether the CMJ height may be capable of detecting the neuromuscular fatigue induced by the dispute of different matches on consecutive days following a long trip performed in uncomfortable conditions.

In team sports it is very important to perform an individual control of training loads to assess the training stimulus (Campos-Vázquez, Toscano-Bendala, Mora-Ferrera, & Suarez-Arrones, 2017), because an excessive stimulus increases the injury risk and an insufficient stimulus may decrease performance (Vanrenterghem, Nedergaard, Robinson, & Drust, 2017). The training load can be categorized in external load (training stimulus) and internal load (physiological stress) (Malone et al., 2015). In soccer, the internal load has been quantified by several methods associated with heart rate such as the Banister's training impulse (Banister, 1991), individual training impulse (iTRIMP) (Manzi, Bovenzi, Franco Impellizzeri, Carminati, & Castagna, 2013), Edwards' method (Edwards, 1993), although these methods are used only by teams with important economic resources (Campos-Vázquez et al., 2017; Gil-Rey, Lezaun, & Los Arcos, 2015). An economic alternative to these methods is rate perception of exertion (RPE). The RPE is easy to use and indicates the physical and psychological stress of the players (Vanrenterghem et al., 2017). However, since it is subjective, in during high-intensity actions with long recovery periods this effort value may be underestimated or overestimated (Scott, Lockie, Knight, Clark, & Janse de Jonge, 2013). This fact makes interesting to analyze whether the RPE values reported after matches could be associated with the changes in CMJ height after consecutive matches in young soccer players.

In light of the aforementioned considerations, this study was designed to examine how the dispute of different friendly matches on consecutive days affects neuromuscular fatigue assessed by the decrease in jump height. Specifically, the aims of the study were (1) to determine the evolution of the change in CMJ height after different friendly matches played on consecutive days and (2) to evaluate if there is a significant association between the changes observed in the CMJ height with respect to the minutes played and the rate of perceived exertion (RPE). Our first hypothesis was that CMJ height would decrease with the succession of matches. Our second hypothesis was

that the changes in jump height would be related to the minutes played and the post-match average RPE values. The expected results could be important because they would provide coaches an orientation regarding the deterioration of the neuromuscular status after different matches played on consecutive days, contributing to prevent injuries due to overload or fatigue.

METHODS

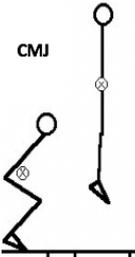
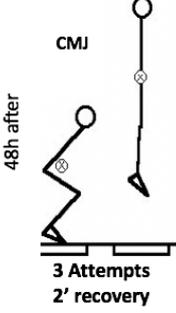
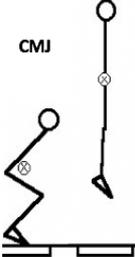
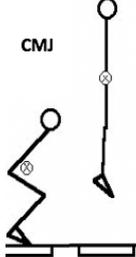
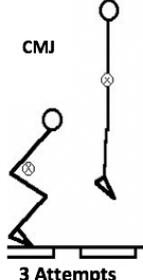
Participants

Twenty-two young male soccer players (age: 16.6 ± 0.8 years, body mass: 68.3 ± 6.5 kg, height: 175.0 ± 6.6 cm) participated in the study. All participants had at least 2 years of experience performing the countermovement jump (CMJ) and with the use of the rate of perceived exertion scale (RPE). None of the participants presented previous injuries that could compromised the jump test. Participants were also informed about study procedure, as they were minors, the parents signed a consent form prior to the beginning of the investigation. The study protocol adhered to the tenets of the Declaration of Helsinki and was approved by the institutional ethics committee.

Experimental desing

This study was designed to analyze the evolution of fatigue induced by a long trip by bus and three friendly matches played on consecutive days. CMJ height was used as an indicator of neuromuscular fatigue (Claudino et al., 2017). The jump height was determined 5 times: (1) Pre-trip (in the place of residence 15 hours before the bus trip), (2) Pre-match 1 (4 hours before match 1), (3) Pre-match 2 (4 hours before match 2), (4) Pre-match 3 (4 hours before match 3), and (5) Post-match (in the place of residence 48 hours after played the match 3 and 15 hours after arriving form another bus trip) (Figure 1). All evaluations were carried out at the same time of the day and under similar environmental conditions ($\sim 22^{\circ}\text{C}$ and $\sim 60\%$ humidity).

Figure 1. Experimental protocol.

CMJ PRE-TRIP	CMJ PRE-MATCH 1	CMJ PRE-MATCH 2	CMJ PRE-MATCH 3	CMJ POST-TRIP
<p>Body mass</p> <p>Height</p> <p>Warm-up 10 minutes</p> <p>CMJ</p>  <p>3 Attempts 2' recovery</p>	<p>4h before match</p> <p>Warm-up 10 minutes</p> <p>CMJ</p> <p>48h after</p>  <p>3 Attempts 2' recovery</p>	<p>Recovery 60 minutes</p> <p>4h before match</p> <p>Warm-up 10 minutes</p> <p>CMJ</p>  <p>3 Attempts 2' recovery</p>	<p>Recovery 60 minutes</p> <p>4h before match</p> <p>Warm-up 10 minutes</p> <p>CMJ</p>  <p>3 Attempts 2' recovery</p>	<p>Warm-up 10 minutes</p> <p>CMJ</p> <p>48h before</p>  <p>3 Attempts 2' recovery</p>
	 Match	 Match	 Match	

Testing procedures

Participants performed a 10-minute standardized warm-up prior to the CMJ test. The warm-up included jogging, dynamic stretching, joint mobility exercises and 6 CMJ performed in increasing order of intensity. After the warm-up, participants performed 3 CMJ on a contact platform (Chronojump-Boscosystem, Barcelona, Spain) and were instructed to jump as high as possible after reaching a knee angle of $\sim 90^\circ$. Participants were instructed to keep their hands on their hips during the CMJ and landing with their legs extended with maximal feet plantar flexion. If some of these requirements were not met, the trial was repeated. To minimize the effects of fatigue, 2 minutes of recovery were implemented between consecutive trials (Jiménez-Reyes et al., 2017).

The first testing session was performed 48 hours before the first friendly match at the participants' sports facility. The second session was preceded by a bus trip of 15 hours, in a sports facility different from the first evaluation. Second, third and fourth sessions were evaluated 4 hours before each friendly match, which were played on consecutive days. Last session took place at the participants' sport facility 48 hours after the last friendly match and after another trip by bus of 15 hours.

Different evaluations of CMJ height were performed on a hard surface with similar characteristics in both sports facilities and participants wore sneakers.

Borg's rate of perceived exertion scale 0-10 (Borg, Hassmén, & Lagerström, 1987) was collected 30 minutes after each match to ensure that the perceived effort was not acute, but related to the minutes played (Campos-Vazquez et al., 2017).

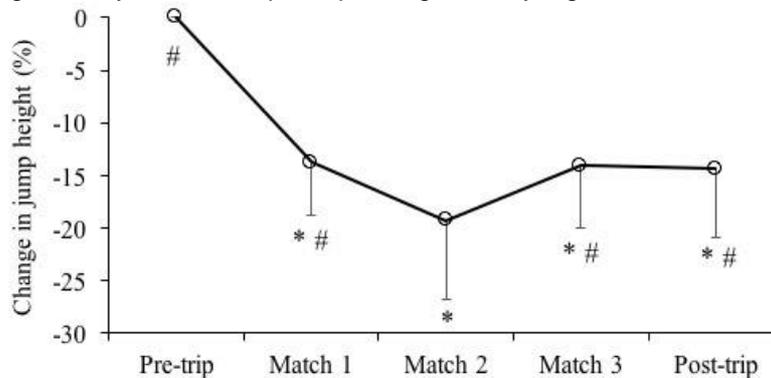
Statistical analysis

Data are presented as means and standard deviations (SD). Before any statistical analysis, the normal distribution of the variables (Shapiro-Wilk test) and the homogeneity of the variances (Levene's test) were confirmed ($P > 0.05$). A repeated-measures analysis of variance (ANOVA) with Bonferroni post-hoc corrections was applied to explore the differences in jump height between the different measurement points (pre-trip, match 1, match 2, match 3, post-trip). Cohen's *d* effect size (ES) was calculated to quantify the magnitude of the differences. The criteria for interpreting the magnitude of the ES were: trivial (< 0.2), small (0.2-0.6), moderate (0.6-1.2), large (1.2-2.0) and extremely large (> 2.0) (Hopkins, Marshall, Batterham, & Hanin, 2009). The association between CMJ height (post-trip vs pre-trip) with the total number of minutes played and the average RPE value of the 3 matches was quantified through the Pearson's correlation coefficient (*r*). In addition, a multiple linear regression model was used to explore the possibility of predicting the change in CMJ height from the total number of minutes played and the average RPE of the 3 matches. All statistical analyses were performed using SPSS software (version 22.0: SPSS, Inc., Chicago, IL, USA). Statistical significance was set at an alpha level of 0.05.

RESULTS

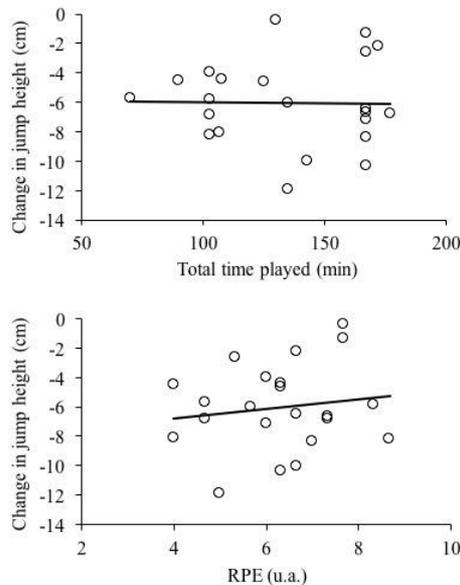
The ANOVA revealed significant differences in jump height between the measurement points ($F = 55.7, P < 0.001, \eta^2 = 0.726$). Bonferroni's post-hoc comparisons revealed that pre-trip CMJ height (41.4 ± 3.9 cm) was significantly higher than match 1 (35.7 ± 3.7 cm, $P < 0.001, ES = -1.47$), match 2 (33.4 ± 3.8 cm, $P < 0.001, ES = -2.07$), match 3 (35.5 ± 2.9 cm, $P < 0.001, ES = -1.53$) and post-trip (35.4 ± 3.6 cm, $P < 0.001, ES = -1.55$) (Figure 2). CMJ height in match 2 was significantly lower than in match 1 ($P < 0.001, ES = 0.61$), match 3 ($P = 0.039, ES = 0.56$) and post-trip ($P = 0.029, ES = 0.53$). There were no significant differences in CMJ height between match 1, match 3 and post-trip.

Figure 2. Percent change in jump height compared to the pre-trip. *, significantly lower than pre-trip; #, significantly higher than match 2.



The change in jump height (post-trip - pre-trip) was not significantly associated with the total number of minutes played ($r = -0.02$, $P = 0.464$) neither with the average RPE value of the 3 matches ($r = 0.15$; $P = 0.249$) (Figure 3). The multiple linear regression model also failed to explain a significant part of the variance of the jump height change ($r^2 = 0.03$, $P = 0.751$).

Figure 3. Association of change in CMJ height (post-trip - pre-trip) with the total minutes played (top panel) and RPE average of the 3 matches played (bottom panel).



DISCUSSION

The present study was designed to elucidate whether the dispute of different friendly matches on consecutive days and a long trip performed in uncomfortable conditions can induce changes in vertical jump height (CMJ). The main finding of the present study was that the CMJ height was always significantly reduced compared to the first evaluation (pre-test), thus confirming the first hypothesis of our study. However, the second hypothesis was not confirmed since no significant correlations were observed between the change in CMJ height and the total number of minutes player or the average RPE value.

The high competitive demands requires that sport professionals take into consideration the training load to prevent injuries and, consequently, to improve sport performance. The CMJ is one of the most important field tests used to evaluate the neuromuscular status and to quantify the training-induced fatigue in athletes (Claudino et al., 2017; Gathercole, Sporer, Stellingwerff, & Sleivert, 2015; Marqués-Jiménez et al., 2017; Watkins et al., 2017; Zurutuza, Castellano, Echeazarra, and Casamichana, 2017). Different kinetic and kinematic variables can be analyzed to evaluate CMJ performance (McMahon, Suchomel, Lake, & Comfort, 2018), being the jump height the most used variable because it is a practical measure that can provide valuable information regarding the athlete's neuromuscular status (Claudino et al., 2017). On the other hand, the rate of

perceived exertion (RPE) is also used for monitoring the training load since it is a valid, inexpensive, non-invasive and easy to use method that allows us to know the internal load of the athletes (Campos -Vázquez et al., 2017; Foster et al., 2001; Impellizzeri, Rampinini, Coutts, Sassi, & Marcora, 2004; Marqués-Jiménez et al., 2017). Therefore, it is interesting to examine whether the results obtained for these two variables follow a similar behavior, that is, to corroborate whether a greater decrease in CMJ height could be associated with higher values of RPE or minutes played.

Our first hypothesis was confirmed since vertical jump height (CMJ) progressively decreased together with the increase in the number of matches played. In line with the results obtained in our study, Thomas et al. (2017) revealed a decrease in vertical jump height in semi-professional footballers after a simulated soccer match. Similarly, Watkins et al. (2017) showed similar results in athletes that performed different exercises that mostly involved the lower-limb muscles. However, the results obtained in female soccer players (Krustrup et al., 2010) and young men (Thorlund et al., 2009) do not agree with the results of the present study. This could be explained by differences in the specific development of fatigue between genders or, even, by the competitive level. Therefore, the results of the present study confirm that CMJ height can be a valid indicator to evaluate the fatigue induced by different matches played on consecutive days.

Another possible explanation for the decrease in vertical jump performance (CMJ) could be the long trip in uncomfortable conditions performed by the participants. Based on this, Chapman, Bullock, Ross, Rosemond & Martin (2012) analyzed the effect of a trans-national trip in different jumping tests over several days, observing a decrease in CMJ height after the trip, which is in line with the results of the present study. However, we must be careful when interpreting these results because the means of transport used in both studies were different (airplane and bus, respectively), probably affecting comfort conditions. Therefore, future studies are necessary to analyze the effects of different means of transport (eg., bus, train, plane, etc.) on the neuromuscular status of the athlete.

Our second study hypothesis was not confirmed since no significant correlations were observed between the change in CMJ height with respect to average RPE values of the matches or the total minutes played. In agreement with the results of our study, although using the respiratory and muscular s-RPE, Gil-Rey et al. (2015) did not find significant correlations between the training load and the change in CMJ height in young soccer players of different competitive levels (elite and non-elite). Similarly, Arcos, Yanci, Mendiguchia, & Gorostiaga (2014) have obtained similar results in professional players when comparing the total accumulated minutes (training and matches) and changes in the jump height during 9 weeks. It would be necessary to conduct more studies to determine whether the neuromuscular fatigue induced by different matches played on consecutive days influences the vertical jump height.

Several limitations should be mentioned in this study: (1) the main limitation was that no control group was used; (2) no objective measures were used to quantify the training load. Future research should focus on the evaluation of neuromuscular performance of young soccer players in tournaments played in the pre-competitive and competitive periods in which several soccer matches are played on consecutive days. Due to the little scientific information available, it would be interesting to explore the effects induced on neuromuscular performance and recovery of athletes travelling by bus, or others cheaper means of transport, during long trips.

CONCLUSION

The present study confirms that the vertical jump height (CMJ) is able to detect the fatigue induced by different soccer matches played on consecutive days. However, the decrease in CMJ height does not seem to present a high association with the RPE values nor with the total number of minutes played. The results obtained could be of interest for fitness coaches to make them aware that a trip of long duration performed in uncomfortable conditions, followed by different soccer matches performed on consecutive days, may compromise the neuromuscular status of the players, consequently increasing the risk of injury and decreasing sport performance.

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