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Original Research

Assessment of Neuromuscular Fatigue 24 hours After a Futsal Simulated Protocol in University Female Athletes

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ABSTRACT

International Journal of Exercise Science 16(1): 205-216, 2023. The purpose of this study was to identify changes in neuromuscular performance variables evaluated through the countermovement jump test before and after (0 hours, after session and 24h post) of a simulated futsal protocol in young university female athletes. Fourteen eumenorrheic, healthy and experienced female futsal players were randomly assigned to an intervention group n = 7) or a control group (n = 7). Both groups performed three countermovement jumps before and after the protocol using an inertial system device. The intervention group completed a short-term functional agility and fatigue protocol that simulated the characteristics of futsal, while the control group did not perform any exercise. The results showed a reduction in peak flight time (p = 0.049; d = 0.586), peak concentric work (p = 0.03; d = 1.819) and peak maximum force (p = 0.02; d = 0.782) comparing experimental and control group. No changes in other variables examined were noted between conditions ($p > 0.05$). These findings indicate that the changes in neuromuscular performance variables, evaluated through a simulated protocol, are established as determinants in the definition of peripheral fatigue in futsal practitioners until 24 h after a demanding intervention.

KEY WORDS: Monitoring, women, countermovement jump

INTRODUCTION

Futsal is a team sport, considered a more rigorous version of football because of its size on the field (21) and its multiple demanding actions, i.e., sprints, high intensity, jumps, acceleration, deceleration and changes of direction during training and competition (19). This can generate neuromuscular effects of peripheral fatigue (40) that affect the performance capacity of the athlete. Futsal is a team sport, considered a more rigorous version of football because of its size on the field (21) and its physical demands.

For this reason, the characterization of several sports (e.g., tennis, badminton, rugby, hockey, cycling, football, handball, basketball, water polo and cycling) (31) and in this case futsal establish actions of repetitive and intermittent movements of a maximum and sub maximum levels with short periods of relative recovery that triggers a great mechanical tension in the lower limbs (4).

Likewise, futsal is a complex sport that involves many activities and (jumps, tackles speed changes and direction) (31) such high demand actions in phases of acceleration and deceleration of race, lead to a difficulty in metabolic and neuromuscular recovery, which generates a lower recruitment of motor units (24, 32, 15, 35, 36) decreasing explosive performance, and maximum strength, thus compromising the individual performance and injury risk factor (31, 44, 54).

Regarding female soccer, and in particular for futsal, very little information is available on neuromuscular changes after training or match, and the time evolution of these responses has not been fully examined. On the other hand, evaluate the acute effects after a match is not always possible, due to the context, the organizational and specific sport needs. In this sense, for this reason, this study aims to identify changes in neuromuscular performance variables in order to evaluate the peripheral fatigue state using the CMJ in young female futsal players.

METHODS

Participants

Fourteen young and healthy female university futsal players participated in this study. All of them were competing with their college team during the season and had no previous injuries that could compromise their performance. Participants read and signed an informed consent form before their participation. The study was approved by the Institutional Ethics Committee of the Fundación Universitaria Area Andina (CV2018 B109) and was conducted in accordance with the principles of the Declaration of Helsinki and the ethical standards of the International Journal of Exercise Science (47). Participants were randomly assigned to experimental or control group, and their characteristics are displayed in Table 1.

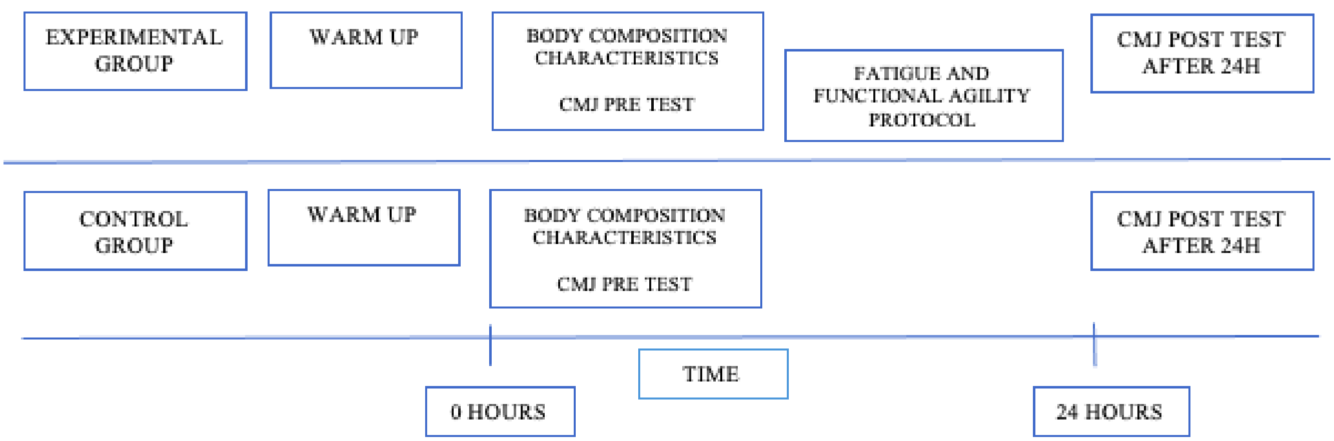
Table 1. Descriptive characteristics (n = 14).

Characteristics	Mean ± SD
Age (yrs)	21.2 ± 2.95
Height (cm)	161.06 ± 2.93
Body mass (Kg)	57.52 ± 4.83
Body age	25.4 ± 5.40
Training experience (yrs)	10.4 ± 5.06

Protocol

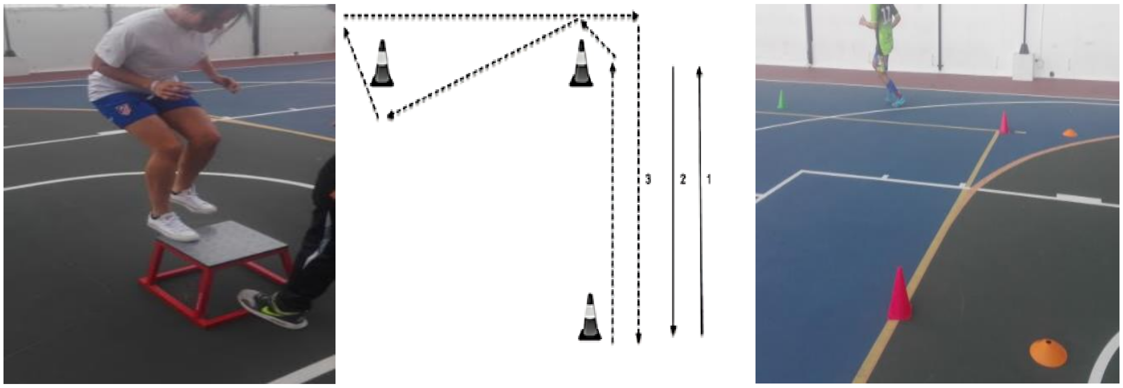
A schematic representation of the protocol design is shown in Figure 1. All participants completed a ten-minute standardized warm-up before the jump test. Warming included jogging, dynamic flexibility, joint mobility exercises and 3 CMJ performed in increasing order of intensity. Subsequently, anthropometric measurements of were assessed. A stadiometer was used for measuring the height (Seca Corp. Chino, CA, USA) and for body mass, body fat and average lean muscle weight, a digital scale (Omron BF-508, Omron Healthcare Co., Kyoto, Japan) was employed. BMI was calculated as body mass in kilograms divided by height in metres squared (kg/m2). Neuromuscular performance measurement was performed for all athletes, who performed three standardised countermovement jumps (CMJ) before and after (0 and 24 hours) a functional fatigue and agility short-term protocol (FAST-FP) (50), which simulates the futsal characteristics. This measurement was performed with reference to the Bosco test (37) with a GYKO inertial device (Microgate inertial sensor system, Bolzano, Italy), with an acquisition frequency of 1000 Hz. Participants were instructed to jump as high as possible after reaching a knee angle of 90º, to keep their hands on the pelvis during CMJ test and to land with their legs extended with their feet maximum bending until last. If any of these requirements were not met, the test was repeated. To minimize the effects of fatigue, 2 min of recovery were implemented between consecutive trials (36). All measurements were taken by the study's leading research faculty in the company of sports training professionals trained for such activities.

Figure 1. Protocol short-term functional agility of fatigue protocol.



FUTSAL SIMULATION PROTOCOL: The FAST-FP (50), which simulates the characteristics of futsal consists in the following tasks. Initially, a series of agility exercises were performed, including (10) continuous jumps in a 30 cm drawer for 20 seconds with a metronome set at 220 beats per minute (Figure 2a). Consecutively, they had to run at points marked with three cones that were organized in the form of L, each cone was placed 4.11 meters away. Each athlete ran this distance toward a cone, back and forth to the starting cone and then returned to the second cone where they ran around and headed straight for the third cone (Figure 2b and 2c).

After L exercise, the participants performed 5 consecutive CMJ, remaining within 80% of their maximum vertical jump recorded before the start of the protocol (Figure 3a). After the vertical jumps, each athlete ran down and back on an agility ladder where, on the first and third time, they had to run forward, ensuring that both feet touched each other within each stairway space (Figure 3b).



a) b) c)

Figure 2. a) Continuous jumps in a 30 cm drawer for 20 seconds with a metronome set at 220 beats per minute. b) exercise scheme in L, short-term functional agility of fatigue protocol. c) Agility exercise in L

a) b) c)

Figure 3. a) Outline exercise of consecutive countermovement jumps. b) Agility exercise with coordination ladder. c) Rating of jumps with GYKO inertial device

Statistical Analysis

The variables obtained from the individual CMJ test were: peak flight time, peak contact time, peak eccentric duration, peak concentric duration, peak eccentric work, peak concentric work, jump height, peak maximum velocity, peak maximum power, peak maximum force, peak rate of force development and peak time to maximum force. All data were analyzed using the software JASP 0.16 (University of Amsterdam, Amsterdam, The Netherlands). An a priori power analysis was done using G*Power 3.1.9.7 (Düsseldorf, Germany) for within group main effects of repeated measures ANOVA using and effect size of 0.4 to achieve 85% power. The resulting analysis indicated a sample size of 14 was needed to achieve power based upon $\eta 2 = 0.391$ from Satkunskiene et al. 2020 (62). Statistical analysis was conducted using a 2 × 2 mixed ANOVA (time x group) analysis with a Bonferroni post-hoc test as warranted. Estimates of effect size for main effects were calculated using the partial eta squared ηp^2 and interpreted as: 0.01—small; 0.06—medium; ≥ 0.14—large (16). Cohen's *d* effect sizes (d) were calculated between conditions and interpreted as: 0.2—small; 0.5—moderate; 0.8—large (19). Significance was set at p ≤ 0.05 a priori. All data are presented as mean ± standard deviation (SD).

RESULTS

A two-way mixed model ANOVA (Table 2) revealed significant effect of peak flight time (P = 0.014, ηp² = 0.125), peak concentric work (*p* = 0.036, ηp² = 0.082), jump height (*p* = 0.013, ηp² = 0.153), peak maximum velocity (*p* = 0.038, ηp² = 0.077) and peak maximum force (*p* = 0.049, ηp² = 0.219).

Table 2. Performance Variables of Athletes' Jump.

Performance variables pretest jump - post test (24) for EG and CG

Data analysis with a mixed ANOVA

	EG			CG			P-value (ηp2)		
	Pre test	Post test (0h)	Post test (24h)	Pre test	Post test (0h)	Post test (24h)			
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Time	Group	T x G
PFT [s]	0.52 ± 0.02	0.51 ± 0.02	0.50 ± 0.02	0.48 ± 0.04	0.49 ± 0.03	0.48 ± 0.03	0.014 (0.125)	0.02 (0.259)	0.014 (0.168)
PCW [J/Kg]	7.30 ± 0.70	7.14 ± 0.42	7.18 ± 0.43	6.35 ± 0.74	6.00 ± 0.91	6.43 ± 0.90	0.036 (0.082)	0.581 (0.044)	0.010 (0.434)
JH [cms]	33.38 ± 3.04	32.56 ± 2.87	31.17 ± 2.79	29.02 ± 5.25	29.64 ± 4.05	29.36 ± 3.98	0.013 (0.153)	0.051 (0.220)	0.014 (0.170)
PMV [m/s]	2.64 ± 0.13	2.62 ± 0.15	2.54 ± 0.14	2.45 ± 0.16	2.50 ± 0.20	2.50 ± 0.21	0.038 (0.077)	0.047 (0.225)	0.020 (0.132)
PCT [s]	0.94 ± 0.13	1.10 ± 0.10	1.31 ± 0.50	1.14 ± 0.48	1.21 ± 0.32	1.13 ± 0.31	0.354 (0.083)	0.290 (0.098)	0.740 (0.010)
PED [s]	0.62 ± 0.09	0.80 ± 0.09	0.95 ± 0.34	0.85 ± 0.38	0.78 ± 0.29	0.82 ± 0.21	0.268 (0.104)	0.154 (0.144)	0.777 (0.007)
PCD [s]	0.30 ± 0.10	0.27 ± 0.04	0.28 ± 0.03	0.23 ± 0.04	0.36 ± 0.34	0.24 ± 0.03	0.268 (0.104)	0.154 (0.144)	0.777 (0.007)
PEW [J/Kg]	(-) 4.80 ± 0.97	(-) 6.61 ± 1.02	(-) 7.02 ± 1.05	(-) 6.22 ± 1.41	(-) 5.49 ± 1.60	(-) 4.17 ± 4.86	0.804 (0.018)	0.068 (0.201)	0.240 (0.113)
PMP [W/Kg]	58.70 ± 7.63	61.16 ± 8.83	54.00 ± 8.16	53.38 ± 12.48	55.85 ± 8.64	58.54 ± 12.75	0.467 (0.061)	0.049 (0.223)	0.673 (0.015)
PMF [N/kg]	27.72 ± 2.31	28.74 ± 3.47	25.03 ± 2.32	28.38 ± 4.37	30.18 ± 6.76	30.26 ± 6.89	0.049 (0.219)	0.011 (0.315)	0.327 (0.080)
PRFD [N/kg/s]	45.28 ± 20.48	39.95 ± 27.29	16.60 ± 14.95	40.58 ± 15.18	33.15 ± 22.54	41.15 ± 14.65	0.796 (0.019)	0.274 (0.102)	0.314 (0.084)
PTMF [s]	0.16 ± 0.11	0.18 ± 0.06	0.13 ± 0.07	0.09 ± 0.07	0.09 ± 0.07	0.11 ± 0.08	0.884 (0.010)	0.360 (0.082)	0.107 (0.202)

EG (Experimental Group); CG (Control Group); Partial eta squared effect size (ηp2), T x G (Time x group interaction) SD (standard deviation) (-): negative PFT [s]: peak flight time, PCW [J/Kg]: peak concentric work, JH [cms]: jump height, PMV [m/s]: peak maximum velocity, PCT [s]: peak concentric time, PED [s]: peak eccentric duration, PCD [s]: peak concentric duration, PEW [J/Kg]: peak eccentric work, PMP [W/Kg]: peak maximum power, PMF [N/kg]: peak maximum force, PRFD [N/kg/s]: peak rate of force development, PTMF [s]: peak time to maximum force.

Bonferroni's post-hoc comparisons revealed that EG showed significant changes in: peak flight time between pre and post (24h) (p = 0.049; d = 0.586), peak concentric work pre and post (0h) (p = 0.03; d = 1.819), jump height pre and post (24h) (p = 0.049; d = 0.587) and peak maximum force pre and post (24h) (p = 0.02; d = 0.782). On the contrary, the change in peak flight time (pre-post 0h) (p = 1.0; d = 0.316), peak concentric work (pre - post 24h) (p = 1.0; d = 0.186), jump height (pre - post 0h) (p = 1.0; d = 0.219) and peak maximum force (pre - post 0h) (p = 1.0; d = 0.215), reported no significant differences.

DISCUSSION

In recent years there has been an interest in the effects of neuromuscular fatigue in the performance of explosive sports, (1). Previous studies have shown a fatiguing effect post futsal match (21), however, not using specific protocols that reproduce the demands of sport. Therefore, in the present study the aim was identify changes in neuromuscular performance variables evaluated through the countermovement jump test before and after (0 and 24 hours) of a simulated futsal protocol in a group of young university female athletes on performance variables of CMJ on time of evaluation after the intervention protocol. We found that changes in variables of countermovement jump recorded with the inertial system tool (GYKO) were significant after the intervention protocol. Therefore, flight time, peak concentric work, jump height and peak maximum velocity establish a considerable decrease over the measurement times compared to the control group due to compliance requirements.

Apparently, different sports performance-related parameters couldn’t be affected during the menstrual cycle among futsal female athletes according to Meignié A, (46), but the neuromuscular fatigue may induce important alterations on the kinematics of movement (32,14), which reflects directly on the movement technique and final performance of competition. Therefore, it is interesting to examine whether the results obtained for these variables follow a similar behavior, that is, to corroborate whether a greater decrease in CMJ height could be associated with higher values of fatigue in athletes.

Our hypothesis was confirmed since vertical jump height, peak concentric work, peak maximum velocity and peak flight time, (CMJ) decreased together with the increase in the hours post simulation futsal protocol. In line with the results obtained in our study, one investigation (22) revealed a decrease in vertical jump height in semi-professional footballers after a simulated soccer match. Similarly, Goodall S, (36) showed similar results in athletes who performed different exercises that mostly involved the lower-limb muscles. However, 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 (32) can be a valid indicator to evaluate the fatigue induced by different matches played on consecutive days.

To our knowledge, this is the first study that has examined the explosive strength and performance of female futsal players post fatigue simulation protocol, explaining the decrease in vertical jump performance CMJ could be central processes contribute significantly to the neuromuscular fatigue experienced in the days after soccer (futsal) fatigue protocol.

Based on this, another study (63) analyzed the effect of protocol simulated that elicited decrements in maximum voluntary contraction (MVC) that remained unresolved since 24 until 72 hours, as well as measures of jump performance observing a decrease in CMJ variables after the protocol, due to muscle microdamage (38), which is in line with the results of the present study. Additionally, an important change observed in this study was the reduction in jump height and peak max velocity immediately after the first 24h post exercise, is in accordance with our results observed in female players immediately after a sport simulation (3).

Thus, the acute reductions in CMJ performance, and the decline in explosive strength, indicate that different aspects of force generating capacity are compromised in response to a female soccer match simulation. It can also be concluded that CMJ performance and explosive strength are similarly affected in male and female players (3). High-force muscle actions, such as those performed during futsal, can lead to structural muscle disruptions, which can explain the alteration of the force-generation capacity induced a decrement on sprint time, changing the kinematics of the lower limbs immediately 24 hours after the Exercise (55,52, 22, 11,3).

Therefore, the results of this study confirm that the variables recorded through the jump have a variation, which justifies a lower motor performance, due to presence of peripheral fatigue (40, 45) which affects the development of the execution on concentric work and peak velocity of lower limbs, flight time (8) and jump height (1, 4, 28, 17) highlighting these aspects as valid fatigue indicators, which are induced by different acceleration actions, decelerations, high intensity movements and velocity changes are particularly harmful to skeletal muscle as evidenced in the study of Nédelec and Dal Pupo (55,22).

In consequence, it is confirmed on hypothesis posed, about the changes on neuromuscular performance variables after the simulation protocol application, establishing a state of residual fatigue during day following to the intervention. For this reason, the results obtained in our study and in relation to Castagna and Milioni, (16,47) are determined that the kinematic variables recorded, progressively decrease through the periods after physical demand.

For this reason, the importance in the control of performance variables of jump is highlighted (28) in athletes due to the demands of the competition taking into account the load parameters in training in order to monitor sports performance (13, 25, 49, 53, 57 ,58) as well as any adverse circumstances that affect the integrity of the athlete, reducing the possibility of injury (30,62,63).

Finally, there are limitations in this study that require consideration. Specifically, the small number of athletes in this study was reduced as it was assessed for convenience. However, the contribution of the present study confirms that the changes in neuromuscular performance variables, evaluated with the countermovement jump test through a simulated protocol, are established as determinants in the definition of peripheral fatigue in futsal female practitioners.

Therefore, this alteration in the recruitment of muscle motor units in athletes could generate a higher risk of injuries that affect sports performance.

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