






## The effects of neuromuscular performance and perceptual parameters in futsal athletes playing consecutive games

### Efeito do desempenho neuromuscular e dos parâmetros perceptuais em atletas de futsal em jogos consecutivos

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#### ABSTRACT

**Aim:** To analyze the effects of indoor soccer on neuromuscular performance and subjective perceived exertion. **Methods:** Fourteen male athletes, belonging to a youth futsal team, were monitored during the qualifying phase of the Paranaense Championship, with games held on four consecutive days. The vertical jump tests Squat Jump (SJ); Counter Movement Jump (CMJ) and subjective perception of effort (SPE) were performed after each game. **Results:** The analyzes based on the magnitude showed that the CMJ values in game 2 were probably lower compared to game 1 (ES = -0.46 small) and game 4 (ES = -0.53 moderate) respectively. In addition, SJ had lower values in game 2 compared to game 1 (moderate ES = -0.56) and possibly game 3 (small ES = -0.45). Regarding PSE, significant differences were found between the relative averages of games 1 and 2 (p = 0.04), 1 and 3 (p = 0.01) and 3 and 4 (p = 0.01). In addition, game 1 showed very likely and almost certain lower values compared to games 2 (ES = -0.97 large) and 3 (ES = large), possibly lower values in game 2 and 3 (ES = -0.45 small) and very likely minor changes in game 4 compared to 2 (EF = -0.83) and 3 (ES = 1.01 large) respectively. **Conclusion:** The investigated futsal championship, with games held on four consecutive days, decreased the performance of vertical jumping tests throughout the competition associated with increased effort perceived in under 17 year old athletes.

**Key-words:** Team sports, Physical performance, Fatigue, Muscle damage.

#### RESUMO

**Objetivo:** Analisar os efeitos de jogos de futsal no desempenho neuromuscular e percepção subjetiva de esforço. **Métodos:** Quatorze atletas do sexo masculino, pertencentes a uma equipe de futsal juvenil foram monitorados durante a fase classificatória do Campeonato Paranaense, com jogos realizados em quatro dias consecutivos. Os testes de salto vertical Squat Jump (SJ); Counter Movement Jump (CMJ) e percepção subjetiva de esforço (PSE) foram realizados após cada jogo. **Resultados:** As análises baseadas na magnitude demonstraram que os valores de CMJ no jogo 2 foram provavelmente menores comparado ao jogo 1 (ES= -0,46 pequeno) e ao jogo 4 (ES= -0,53 moderado) respectivamente. Além disso, SJ apresentou menores valores no jogo 2 comparado ao jogo 1 (ES= -0,56 moderado) e possivelmente ao jogo 3 (ES= -0,45 pequeno). Em relação a PSE foram encontradas diferenças significativas entre as médias relativas dos jogos 1 e 2 (p=0,04), 1 e 3 (p=0,01) e 3 e 4 (p=0,01). Além disso, o jogo 1 apresentou valores muito provavelmente e quase certo menores comparados aos jogos 2 (ES= -0,97 grande) e 3 (ES= grande), valores possivelmente menores no jogo 2 e 3 (ES= -0,45 pequeno) e mudanças muito provavelmente menores no jogo 4 comparado ao 2 (EF=-0,83) e ao 3 (ES= 1,01 grande) respectivamente. **Conclusão:** O campeonato de futsal investigado, com jogos realizados em quatro dias consecutivos, diminuiu o desempenho dos testes de saltos verticais ao longo da competição associada com o aumento da percepção de esforço em atletas sub 17 anos.

**Palavras-chave:** Esportes Coletivos, Desempenho físico, Fadiga, Dano muscular.

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## Introduction

Futsal is a sport characterized by high-intensity intermittent efforts and short recovering periods [1,2]. Moving fast and intensively is particularly important during a match [3-5], once aerobic (power and capacity) and anaerobic components are highly associated to an athlete's good performance [1,2-8]. Although one's aerobic system is predominantly important for the sport, anaerobic ability aptitude demonstrated in actions of muscular power is related to decisive activities within a match, such as sprint, jumps, braking, direction changing, and kicking [1,2].

In Brazil and other countries, futsal teams are allowed to play 2-4 matches a week on consecutive days in short tournaments [9,10]. High intense matches may lead to delayed onset muscle soreness (DOMS), inflammation, elevated subjective perception of effort (SPE) and of muscle function in futsal athletes [2,11-13].

Though the need of adequate recovery levels for good match performance, the resting interval in-between matches may not be long enough to enable adequate recovery to futsal athletes [14]. Thus, vertical jump tests are sensible to identify fatigue after a futsal match [9,14,15].

In this sense, it is important to understand the physiological impact of consecutive matches in physical performance by analyzing athletes using practical reliable tests. Testing allows planning adequate recovery strategies and potentiating match performance. Therefore, the present study aims to identify the effects of consecutive futsal matches in the neuromuscular performance of vertical jumps and in SPE in futsal athletes.

## Methods

### *Experimental design*

The Ethics Committee on Research (Human Beings) of the Western Paraná State University (UNIOESTE) approved this research project. Certificate of Presentation of Ethical Appreciation (CAAE) #52557415.0.0000.0107, decree #1.838.509.

### *Participants*

Fourteen male athletes (age =  $16.5 \pm 0.51$  years, body mass =  $67.5 \pm 11.1$  kg; height =  $1.73 \pm 0.08$  cm; BMI =  $22.5 \pm 2.3$  kg/m<sup>2</sup>) took part at this study. The sample selection of the study was intentional and non-probabilistic: inclusion criterion was being an athlete who belongs to a youth futsal team that plays in regional and state championships.

Researchers carried out data collection throughout the classifying phase of the Campeonato Paranaense sub 17 anos de Futsal (Youth Futsal Championship of the State of Paraná, Brazil – under-17 male athletes). Athletes were used to systematically practice five times a week (~90-minute training sessions), at night, and play friendly and official games on the weekends. Athletes underwent 60 to 90-minute training sessions. Training focused on improving their technical/tactical and physical performance (specifically concerning their anaerobic and aerobic systems). Anaerobic training consisted of plyometric exercises, explosive strength exercises, and multiple sprints; aerobic training consisted of small-sided matches and running with long and short intervals.

### Procedure

Participants underwent five experimental sessions with a 24-hour interval in-between sessions. In the first session, that took place one week before data collection, researchers carried out each athlete's anthropometric analysis in order to characterize the sample of the study. From the second to the fifth sessions, subjects underwent vertical jump tests (Squat Jump (SJ)) and Countermovement Jump tests (CMJ) immediately after each match of the futsal tournament.

A scale with a stadiometer (Balmak model Labstore – maximum load = 150 kg, minimum load = 1 kg, 50g scale, Class III) measured the athletes' body mass and structure, according with Guedes & Guedes protocol (2006) [16]: athletes were wearing their team uniform (t-shirt, shorts, and socks – no sneakers) [16]. Research also calculated their Body Mass Index (BMI) [17].

For the CMJ test, players stood in orthostatic position, with their hands on their hips, flexed their knees to a self-selected angle, and performed the concentric phase with as much power as possible. For the SJ test, players remained in crouched position, for at least 3 seconds, with their hands on their hips and their knees flexed at an angle of  $\sim 90^\circ$  [18]. A Jumping Mat (Multisprint®, Hidrofit®, Brazil) registered the height of the jump of each athlete. Subjects jumped without moving their arms to isolate lower-limbs power. Each participant carried out three jumps with a 30-second interval in-between each trail. Research considered the best outcome out of the three jumps for analysis. Researchers treated jump height as a performance indicator [19], once it represents high reproducibility [20].

The study used Borg's CR-10 scale [21] adapted by Foster *et al.* [22] (previously used in futsal athletes [13]) to obtain subjective perception of effort (SPE) indexes 15-30 minutes after each match. Athletes answered the question "What was your training session like?" using a scale that ranged from 0 to 10. To normalize internal load, such value was multiplied by the total time length each athlete played actively on the court during each match.

The study used the Shapiro-Wilk test to verify data normality, Levene test to evaluate homoscedasticity, and Mauchly test to check data sphericity. The research used measures of central tendency (mean) and dispersion (standard deviation) to describe investigation variables. An ANOVA of repeated measures compared the differences of CMJ, SJ, and PSE variables in the after game, as well as Bonferroni's post hoc test. The study adopted a significance level of  $p < 0.05$  for every analysis and interpreted data by using the statistical program Statistical Package for Social Science (SPSS) 20.0®. In agreement with Hopkins [23], the research used magnitude-based inference analyses to evaluate the differences of performance markers and SPE concerning each match. Researchers assessed the smallest worthwhile change (that is,  $0.2 \times$  initial standard deviation based on the effect size (ES)) and determined confidence intervals (CI) of 90%. Possibilities of quantitative changes (higher/trivial/lower) were evaluated qualitatively:  $<1\%$ , almost certainly not;  $1\%$  to  $5\%$  very unlikely;  $5\%$  to  $25\%$  unlikely;  $25\%$  to  $75\%$  possible;  $75\%$  to  $95\%$  likely;  $95\%$  to  $99\%$  very likely;  $> 99\%$  almost certain. The true difference was evaluated as 'clear' when chances of obtaining positive or negative results were  $> 10\%$ . The study defined ES according to Cohen's classification [24]:  $<0.2$ : trivial;  $0.2$ - $0.5$ : low;  $0.5$ - $0.8$ : moderate;  $>0.8$ : high.

## Results

Tables I and II present the average values of CMJ and SJ after each match throughout the 4-consecutive-day championship. Research did not find significant differences for both tests ( $p > 0.05$ ) among matches. However, the magnitude-based inference analysis showed CMJ values concerning the 2<sup>nd</sup> match were probably lower when compared to the 1<sup>st</sup> match (ES= -0.46 low) and the 4<sup>th</sup> match (ES= -0.53 moderate). Furthermore, the 2<sup>nd</sup> match showed probably lower values of SJ when compared with the 1<sup>st</sup> match (ES= -0.56 moderate) and possibly lower compared with the 3<sup>rd</sup> match (ES= -0.45 low). Results were uncertain for every other comparison.

**Table I** - Values of mean and standard deviation of CMJ performance after four-consecutive-day matches.

	After	After	ES; Difference (90% CI)	% Change (Classification)
CMJ (cm) (J1xJ2)	37.55 ± 4.86	35.1 ± 3.88	-0.46 (-1.09; 0.18 ± 0.64)	5/20/75 <i>Probably</i>
CMJ (cm) (J1xJ3)	37.55 ± 4.86	36.7 ± 3.7	-0.15 (-0.78; 0.48 ± 0.63)	17/38/44 <i>Uncertain</i>
CMJ (cm) (J1xJ4)	37.55 ± 4.86	37.3 ± 3.92	-0.05 (-0.67; 0.58 ± 0.62)	25/42/33 <i>Uncertain</i>
CMJ (cm) (J2xJ3)	35.1 ± 3.88	37.55 ± 4.86	0.40 (-0.22; 0.02 ± 0.62)	71/24/5 <i>Uncertain</i>
CMJ (cm) (J2xJ4)	35.1 ± 3.88	37.3 ± 3.92	0.53 (-0.07; 1.13 ± 0.60)	82/15/2 <i>Probably</i>
CMJ (cm) (J3xJ4)	37.55 ± 4.86	37.3 ± 3.92	0.14 (-0.48; 0.75 ± 0.61)	43/39/18 <i>Uncertain</i>

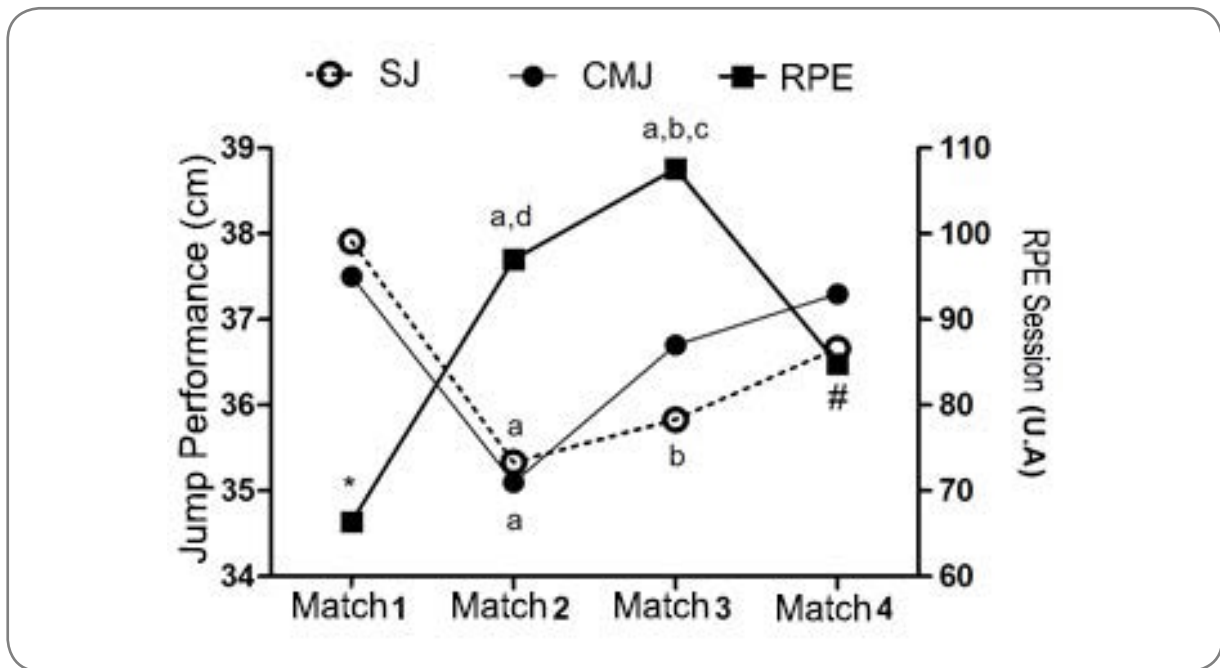
CMJ = Counter Movement Jump; cm = centimeters; J = match; ES = effect size; CI = confidence interval; % = percentual.

**Table II** - Values of mean and standard deviation of SJ performance after four-consecutive-day matches.

	After	After	ES; Difference (90% CI)	% Change (Classification)
SJ (cm) (J1xJ2)	37.91 ± 4.17	35.33 ± 3.7	-0.56 (-1.21; 0.10 ± 0.66)	5/15/82 <i>Probably</i>
SJ (cm) (J1xJ3)	37.91 ± 4.17	35.8 ± 3.4	-0.45 (-1.09; 0.19 ± 0.64)	5/20/75 <i>Possibly</i>
SJ (cm) (J1xJ4)	37.91 ± 4.17	36.5 ± 4.25	-0.27 (-0.97; 0.43 ± 0.70)	13/30/57 <i>Uncertain</i>
SJ (cm) (J2xJ3)	35.33 ± 3.7	35.8 ± 3.4	0.13 (-0.48; 0.74 ± 0.61)	42/40/18 <i>Uncertain</i>
SJ (cm) (J2xJ4)	35.33 ± 3.7	36.5 ± 4.25	0.33 (-0.36; 1.02 ± 0.69)	63/27/10 <i>Uncertain</i>
SJ (cm) (J3xJ4)	35.8 ± 3.4	36.5 ± 4.25	0.22(-0.50; 0.94 ± 0.72)	52/32/16 <i>Uncertain</i>

SJ = Squat Jump cm = centimeters; J = match; ES = effect size; CI = confidence interval; % = percentual.

Figure 1 displays the mean values of jumps (previously reported) and SPE of sessions after each match. The study found significant differences between the relative means of the 1<sup>st</sup> and 2<sup>nd</sup> matches ( $F=158.486$ ;  $p=0.04$ ); 1<sup>st</sup> and 3<sup>rd</sup> matches ( $F=158.486$ ;  $p=0.01$ ); and 3<sup>rd</sup> and 4<sup>th</sup> matches ( $F=158.486$ ;  $p=0.01$ ). Moreover, the 1<sup>st</sup> match presented very likely and almost certain lower values when compared with the 2<sup>nd</sup> (0/3/97; ES= -0.97 high) and the 3<sup>rd</sup> match (0/0/100; ES= high), respectively; the 2<sup>nd</sup> match delivered possibly lower values when compared with the 3<sup>rd</sup> match (5/21/75; ES= -0.45 low); the 4<sup>th</sup> match presented SPE results probably and very probably lower than the 2<sup>nd</sup> match (2/7/91 EF=-0.83) and the 3<sup>rd</sup> match (99/1/0; ES= 1.01 high).



**Figure 1** - Jump performance (centimeters) (CMJ colored circles; SJ white circles) and SPE (arbitrary units) (painted squares) after matches. a - Probably low and moderate CMJ effects relating the 1<sup>st</sup> and 4<sup>th</sup> matches, respectively; a - Probably moderate SJ effect relating to the 1<sup>st</sup> match; b - Possibly low SJ effect relating the 1<sup>st</sup> match. \* $p < 0.05$  significantly different SPE of session between the 2<sup>nd</sup> and the 3<sup>rd</sup> matches; # $p < 0.05$  significantly different SPE of session relating the 3<sup>rd</sup> match; a very likely and almost certain high effect relating the 1<sup>st</sup> match respectively; b - possibly low effect relating the 2<sup>nd</sup> match; c - Very likely high effect relating the 4<sup>th</sup> match; d - Probably high effect for SPE of session.

## Discussion

This study aims to analyze the effects of 4-consecutive-day futsal matches in the neuromuscular performance of under-17 futsal athletes through vertical jump tests. Its main results pointed decreased CMJ performance (2<sup>nd</sup> match vs 1<sup>st</sup> and 4<sup>th</sup> matches), decreased SJ performance (1<sup>st</sup> match vs 2<sup>nd</sup> and 3<sup>rd</sup>), associated with higher SPE after the 2<sup>nd</sup> and 3<sup>rd</sup> matches.

Relating jumping performance, such findings corroborate with Freitas *et al.* [25], carried out with male adult futsal athletes who played 4-consecutive-day matches. Results showed reduced performance in vertical jump tests, and decreased RES-TQ-Sport score related to physical recovery throughout the competition, suggesting fatigue accumulation along the consecutive-day matches. Andersson *et al.* [26] investigated recovery time concerning muscular fatigue and biochemical alterations between two female soccer matches with an active or passive recovery interval in-between them. When comparing both matches, the authors pointed out significant performance decrease relating sprint, CMJ, and peak torque. They did not find significant differences in recovery standards between groups. Such results confirm Ronglan, Raastad & Borgesen [27] that investigated neuromuscular fatigue levels after three-consecutive-day matches, demonstrating significant reduction (4-7%) of strength and speed levels. The incomplete restoration of performance in-between matches and training sessions explains slow recovery rates.

Other collective sports have also suggested performance reduction in consecutive-match situations. When analyzing the efficiency of recovery strategies throughout a 3-consecutive-day basketball tournament, Montgomery *et al.* [28] reported performance decrease in sprint (0.7%) and agility tests (2.0%), as well as reduced ver-

tical jump after the first day of competition, which remained suppressed even after tournament. More recently, Pereira *et al.* [29] analyzed game performance, muscular damage, and neuromuscular fatigue in three simulated matches carried out in a same day with rugby athletes from the Brazilian Rugby Team. Results demonstrated increased levels of creatine kinase (CK) after game, and increased SJ, CMJ, and strength development rates concerning pre and post consecutive games values. Gallo-Salazar *et al.* [30] pointed out neuromuscular reduction concerning lower limbs (jumps and speed) and higher limbs (isometric strength and movement amplitude) on the day after a consecutive tennis match competition.

Within a physiological point of view, increased capability of strength production may be associated with high-intensity efforts, such as maximum sprints, braking, and direction changing [1,2]. Furthermore, exhaustive exercises with movement patterns involving CAE may induce muscular alterations with consequent reflex alterations that may lead to performance decrease in vertical jump [31]. Horita *et al.* [32] pointed out increased sensibility to CAE tests concerning fatigue due to such exercises when compared with testes involving concentric actions exclusively. On the other hand, adaptations occasioned by constant specific training for a determined sport may lead to a protective effect of repetitive exercise, reflecting in lower damaging alteration in jumps [33]. In our study, vertical jump tests showed to be sensible when identifying muscular function decrease throughout matches, specially concerning SJ tests.

Performance decreased in the 2nd and 3rd matches as SPE increased in the same matches (figure 1). Such findings agree with other studies about team sports [12,34,35]. Rowsell *et al.* [34] associated performance decrease to SPE and lower-limbs muscular pain increase in consecutive matches. Furthermore, according to Moreira *et al.* [12,35], high SPE values may be related to stress increase in volleyball and basketball athletes after matches concerning the intensity and importance of a competition.

Reductions in physical and technical performance may be related to neuromuscular and mental fatigue [36,37]. Literature has been demonstrating that mental fatigue limits one's influence over maximum voluntary activation and strength, explosive power, and anaerobic capacity [38,39]. Furthermore, prolonged periods of cognitive activity may also induce mental fatigue rise [37]. Therefore, it is likely that the athletes' performance in vertical jumps after the 2nd and the 3rd matches relates to SPE increase. Once this scale represents a psychophysical measure [41], when approaching it, we must consider both stimulus (work load) and perceptive response. Smith, Marcora, and Coutts [39] demonstrated that an increased perception of effort mediates the negative effects of mental fatigue.

Thus, an athlete's SPE seems to be an easy-applicable low-cost instrument that enables coaches and physical trainers to evaluate and compare stress levels related to several development aspects [1,2,12,13]. SPE is a scale that quantifies internal load. Internal load reflects the integration of peripheral (muscles and joints) and central signs (ventilation) that, when interpreted by using a sensorial cortex, produce the general or local perception of effort to carry out a determined task [21].

## Conclusion

The 4-consecutive-day championship analyzed has led to neuromuscular performance decrease in vertical jump tests throughout the competition in under-17 male athletes, associated with their increased effort perception. Such results may

help coaches and physical trainers planning and prescribing training, especially concerning the characteristics of such tournament, that requires high physical and mental effort during matches.

Deeper studies concerning physical and physiological responses (intensity, game actions, training time length) associated with technical aspects must be carried out for better understanding the relation of these variables.

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#### Potential conflict of interest

No conflicts of interest with potential potential for this article have been reported.

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#### Authors' contributions

Conception and design of the research: Hübner CSB, Nunes RFH, Flores LJF. Data collection: Hübner CSB, Hübner CA. Analysis and interpretation of data: Hübner CSB, Nunes RFH, Flores LJF. Statistical analysis: Flores LJF, Campos FS, Nunes RFH. Obtaining financing: Not applicable. Writing of the manuscript: Hübner CSB, Nunes RFH, Campos FS. Critical revision of the manuscript for important intellectual content: Bertolini GF, Weber MG, Nunes RFH, Flores LJF.

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