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ORIGINAL

JUMP CAPACITY IN CEREBRAL PALSY SOCCER PLAYERS

CAPACIDAD DE SALTO EN FUTBOLISTAS CON PARÁLISIS CEREBRAL

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ABSTRACT

The aims of the present study were to determine in elite soccer players with cerebral palsy the jump height during a squat jump and during a countermovement jump, and to observe the relationship of the anthropometric parameters and the functional class with the jump height and the elastic index. Thirteen "soccer 7" players diagnosed with cerebral palsy took part in the study. The jump height for a squat jump (20.45 ± 4.45 cm) and a countermovement jump (24.33 ± 5.37 cm) was lower than the obtained in other studies in soccer players without cerebral palsy. The height of the players and their body mass index showed a significant correlation with the jump height during a countermovement jump ($r=0.67$ and $r=-0.71$).

KEY WORDS: soccer, strength, power, vertical jump, cerebral palsy, disability.

RESUMEN

Los objetivos del presente estudio fueron determinar en jugadores de fútbol con parálisis cerebral la altura de vuelo durante la realización del salto sin contramovimiento y con contramovimiento, y observar la relación de las variables antropométricas y de la clase funcional con la altura de vuelo y con el índice elástico. Trece jugadores de fútbol 7 diagnosticados con parálisis cerebral participaron en el estudio. La altura de vuelo durante el salto sin contramovimiento (20.45 ± 4.45 cm) y con contramovimiento (24.33 ± 5.37 cm) fue inferior a la obtenida en otros estudios con jugadores de fútbol sin parálisis cerebral. La altura de los jugadores e índice de masa corporal mostraron una correlación significativa con la altura del salto con contramovimiento ($r=0,67$ y $r=-0,71$, respectivamente).

PALABRAS CLAVE: fútbol, fuerza, potencia, salto vertical, parálisis cerebral, discapacidad.

INTRODUCTION

Soccer has been characterized as a physically demanding high intensity intermittent sport (1, 2, 3). The increase in match frequency (4), as well as the specific playing position (5, 6) influences the physical demands of this sport. Furthermore, strength is considered one of the determinant physical capabilities for performance (7). Increasing strength in the lower limbs permits improvements in acceleration and speed in sports techniques like turns and sprints which are important for football (1). High running speeds (24.7 ± 6.1 km · h⁻¹) when in possession of the ball (8), as well as the distance covered at high power (>20 W·kg⁻¹) (9) highlight the importance of strength in the soccer players' lower limbs. For this reason, training to improve the physical performance of players is focussed, among other objectives, on strengthening the lower limbs.

This training seems to be especially important for people with cerebral palsy (CP), due to the effects associated with this disorder (11). CP is a persistent movement and postural disorder, caused by a non-developmental injury to the central nervous system during the early period of brain development (12). There are different types of CP depending on the degree of motor impairment, with spasticity (13) and muscle weakness (14-18) being the most frequent manifestations. Sustained contraction of the anti-gravitational muscle groups, the co-activation of the antagonistic muscles (19-21) and the accompanying weakness of their antagonistic muscles cause biomechanical imbalance which finally results in the longitudinal retraction of the muscles which generates muscle contractures, skeletal deformities and joint instability (13). These effects influence the limitations which people with CP present with regard to

physical activity (22, 23).

However, there are no studies which analyse the strength of the lower limbs in elite soccer players with CP. This strength is considered fundamental for improving sports performance in soccer (24), so that knowing the strength of the lower limbs in footballers with CP would establish a starting point with which to compare future studies carried out on people with the same condition.

The objectives of the present study were, firstly to determine flight height during the performance of a jump with no countermovement (SJ) and a jump with countermovement (CMJ) and secondly, to observe the relation of the anthropometrical variables and functional class with flight height and the index of elasticity in elite soccer players with CP.

METHODS

Participants

Thirteen soccer players (Table 1) belonging to the Spanish national 7 a side soccer team participated in this study. The inclusion criteria for the participants in the study were, therefore, to belong to the Spanish 7 a side national soccer team, to have a valid licence from the Spanish Federation of Sports for people with Cerebral Palsy and the certificate of disability which is necessary to belong to this federation. The participants were classified according to the Classification Committee of the Cerebral Palsy International Sport and Recreation Association (CP-ISRA) as well as the corresponding national classification from the Spanish Federation of Sports for People with Cerebral Palsy. Both requisites are compulsory for participating in official events for people in the CP category. All the participants had more than 5 years experience of football training and had participated in at least three international events organized by official entities (International Paralympic Committee and CP-ISRA). All the players in the present study participated in the Football 7 World Championships for sports people with CP during that season. None of the participants did specific strength training and all trained an average of 4-5 sessions per week. The study was performed with the consent of the Spanish Federation of Sports for people with Cerebral Palsy. All the participants signed the required informed consent form. The procedures followed the guidelines determined by the Declaration of Helsinki (2008) and the Organic Law for the Protection of Data of a Personal Nature (LOPD).

Table 1. General characteristics of soccer players.

Player	Age (years)	Mass (kg)	Height (cm)	BMI (kg / m ²)	CP	TAP	TS
P1	26	63,0	168,7	22,34	6	D.E	2
P2	23	75,1	174,0	24,86	8	D.E	4
P3	31	74,5	175,5	24,34	7	H.E	11
P4	25	61,0	183,2	18,26	7	H.E	2
P5	21	69,3	180,7	21,38	7	H.E	3
P6	28	62,3	171,4	21,33	6	D.E	2
P7	30	65,2	172,3	22,10	7	H.E	9
P8	24	69,1	185,9	20,20	7	H.E	1
P9	30	68,1	178,7	21,48	7	H.E	3
P10	26	61,8	167,1	23,05	5	D.E	9
P11	27	66,0	169,7	23,15	7	H.E	5
P12	22	61,4	170,5	21,24	8	H.E	7
P13	39	66,8	165,6	24,55	6	D.E	12
Mean±SD	27,07±4,75	66,43±4,70	174,10±6,33	22,17±1,85			5,40±3,75

SD=standard deviation, BMI=body mass index, CP=cerebral palsy class, Cerebral Palsy International Sport and Recreation Association, TPA=predominant affection, TS= time in the Spanish soccer team, D.E=spastic diparesia, H.E=spastic hemiparesia.

Experimental Design

The study was carried out during a training camp for the national team to prepare for the World Soccer 7 Championships for people with CP. The training carried out 48 hours before the performance of the tests was of the recovery type to avoid exhausting exercises using low intensity technical and tactical exercises. In the prior sessions specific exercises were performed to familiarize participants with the correct execution of the tests, and explanations and concrete corrections were also given to the players.

The prior warm up to the performance of the jumps for the tests consisted in 3 minutes of jogging, skipping exercises, scalping, leaping and vertical jumps, with a total duration of 10 minutes. The jumps consisted in the performance of 3 SJs and 3 CMJs with 45 s rest between the jumps. There was a 3 minute rest interval between the two types of jump. Flight time was measured with a piezoelectric force platform (Quattro Jump, Kistler, Switzerland). The height reached by the subjects' centre of gravity was determined from the flight time (26). The starting position for the SJ was with approximately 90° knee flexion, with the trunk near to the vertical axis and hands on the iliac crests where they had to stay during the performance of the jump. The starting position for the CMJ was with the knees extended to subsequently perform a countermovement during the impulse phase to a knee flexion of approximately 90°. A slight flexion of the trunk was permitted during the impulse and flight phases (27). Hands were kept on the iliac crests at all times. The time of the best jump was recorded (28, 29). The jumps which did not comply with the determined requirements were considered null. No player made more than three null jumps in either type of jump.

The elasticity index (IE) was calculated with the formula: $IE = [(CMJ - SJ) \cdot 100] / SJ$, where IE is measured in % (27, 30). Intra-individual variability in the height of the jumps was calculated with the variation coefficient (CV)(31): CV

= (SD / Mean) · 100.

Statistical analysis

The results are presented as mean ± standard deviation from the mean (SD). All the variables were normal and satisfied the equality of variances according to the Shapiro-Wilk and Levene tests respectively. The relation between the results obtained in the anthropometrical variables and the jump variables (height of SJ, height of CMJ and IE) was calculated using Pearson's correlation. The values established by Salaj and Marcovic (32): low ($r \leq 0.3$), medium ($0.3 < r \leq 0.7$) and high ($r > 0.7$) were used to interpret the results obtained in these correlations. The relation among the functional class and the jump variables was obtained using Spearman's correlation. The statistical analysis was performed with the Statistical Package for Social Sciences (version 19.0, SPSS Inc, Chicago, IL, USA. Statistical significance was set at $p < 0.05$.

RESULTS

The results obtained by each player and the group mean are presented in Table 2.

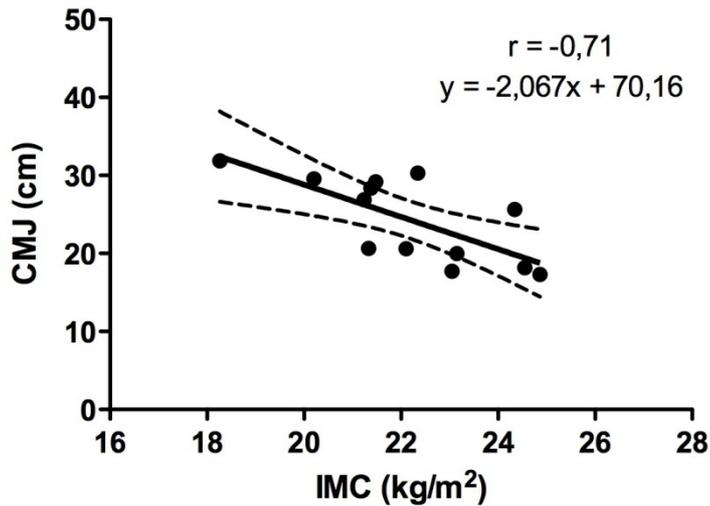
Table 2. SJ, CMJ and IE values (mean ± SD).

Player	SJ		CMJ		IE (%)
	Height (cm)	CV (%)	Height (cm)	CV (%)	
P1	28,08	2,83	30,31	5,42	7,94
P2	14,04	3,91	17,29	4,08	8,77
P3	22,98	3,51	25,65	3,51	11,61
P4	24,94	7,65	31,88	10,16	27,82
P5	23,54	4,96	28,37	7,52	20,51
P6	17,79	8,35	20,63	1,11	15,96
P7	16,94	1,58	20,62	2,52	21,72
P8	19,06	29,20	29,57	8,29	55,14
P9	25,63	9,28	29,17	5,86	13,81
P10	15,04	4,09	17,73	3,49	17,88
P11	16,15	7,49	19,97	2,70	23,65
P12	23,03	2,24	26,89	7,62	16,76
P13	18,33	23,30	18,17	19,56	-0,87
Mean±SD	20,45±4,45	8,34±8,40	24,33±5,37	6,29±4,78	18,51±13,33

SD=standard deviation, SJ=squat jump, CMJ=counter movement jump, CV= coefficient of variation, IE= elastic index.

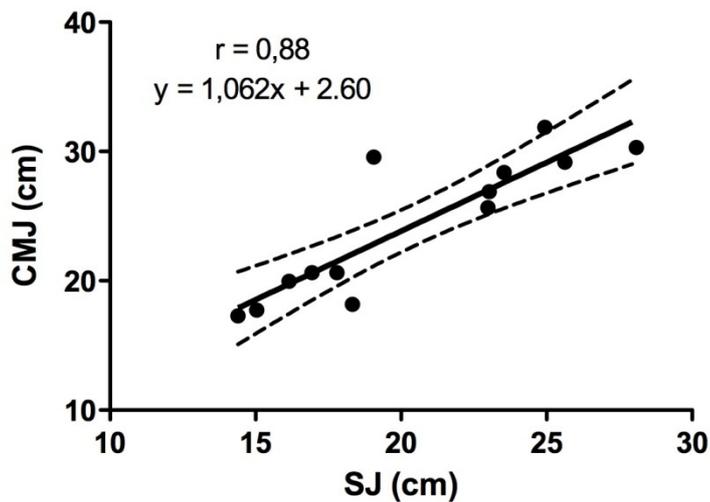
A moderate significant correlation was observed of the height of the soccer players with the body mass index (BMI) ($r = -0.64$, $p = 0.01$) and height of the CMJ ($r = 0.67$, $p = 0.01$), as well as between IE and BMI ($r = -0.63$, $p = 0.02$). A high significant correlation was obtained between CMJ height and BMI ($r = -0.71$, $p = 0.01$) (Figure 1), SJ height and CMJ height ($r = -0.88$, $p = 0.00$) (Figure 2), and IE and the height of the players ($r = -0.70$, $p = 0.01$) (Figure 3).

Figure 1: The relation between body mass index (BMI) and the height of the countermovement jump (CMJ)

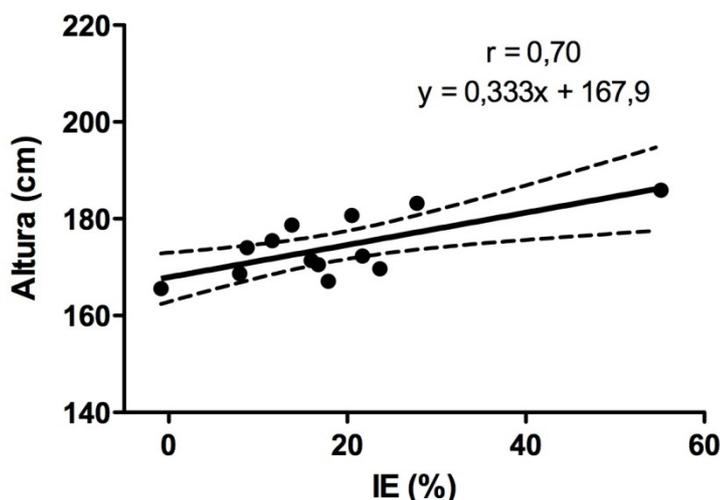


The continuous line represents the regression line \pm the confidence interval at 95% through two discontinuous lines.

Figure 2: The relation between the height of the countermovement jump (CMJ) and the jump with no countermovement (SJ).



The continuous line represents the regression line \pm the confidence interval at 95% through two discontinuous lines.

Figure 3: The relation between the elasticity index (IE) and the height of the participants.

The continuous line represents the regression line \pm the confidence interval at 95% through two discontinuous lines.

The correlations of the mass with the height of the players ($r=0.28$, $p=0.35$), with the BMI ($r=0.55$, $p=0.06$), with the height of the SJ ($r=-0.16$, $p=0.60$), with the height of the CMJ ($r=-0.14$, $p=0.66$), and with the IE ($r=-0.07$, $p=0.83$) were not significant. In the same way the correlations of the height of the SJ with the height of the player ($r=0.33$, $p=0.28$), with the BMI ($r=-0.45$, $p=0.13$), and with the IE ($r=0.07$, $p=0.81$), as well as the height of the CMJ and the IE ($r=0.39$, $p=0.81$), were not significant either. No significant correlation was found between the functional class with the height of the SJ ($r=0.01$, $p=0.97$), or the height of the CMJ ($r=0.08$, $p=0.80$), or the IE ($r=0.21$, $p=0.49$).

DISCUSSION

In a soccer match many actions are carried out at different intensities (8) and both the sprints and the changes of direction are considered essential for performance (33-35). These game characteristics imply that the players should possess physical abilities which permit them to perform quick and powerful movements (36). Vertical jump capacity stands out among these physical abilities. In this study it was observed that jump height recorded in elite soccer players with CP in comparison with players without CP from the Spanish 1st division was 47.57% and 41.24% lower in the SJ and the CMJ respectively. Higher values were also recorded for SJ height and CMJ height in soccer players without CP from the Norwegian 1st division (24 \pm 1.5 years, SJ: 30.3 \pm 1.2 cm and CMJ: 36.0 \pm 0.9 cm) (38) and elite soccer players without CP from Portugal (17.4 \pm 0.6 years, SJ: 41.02 \pm 6.11 cm and CMJ: 42.84 \pm 4.55 cm) (39). Soccer players without CP who were younger than those in our study (junior: 17 \pm 0.5 and cadet: 13.3 \pm 0.6 vs. the present study: 27.7 \pm 4.7 years) also obtained higher values: 35.08% for the SJ and 28.02% for the CMJ in junior players (40) and 32.06% for the SJ and 28.57% for the CMJ in cadets (41). Although in junior girl soccer players without CP higher values were found for the CMJ, this difference was smaller (14.3%). The values of jump height obtained in the present study were only higher than those

recorded in primary school children without CP of between 6 and 8 years of age (36.44% in the SJ and 34% in the CMJ) (42). Different conditions associated with CP could have had an influence on the lower height reached by the centre of gravity during the SJ and CMJ in elite soccer players with CP, with regard to that obtained in other studies (38-40): the lesser recruitment of motor units (43-46), the asymmetric recruitment of the same units during maximum voluntary contractions (45), as well as the co-activation of the antagonist muscles (47) could have contributed to the deficit in force production. The low levels of explosive strength and elastic-explosive strength obtained in the present study support the recommendation of the American Association of Physical Therapy (11) and other authors (48) to carry out specific strength training with people with CP.

Another consequence of CP was the great intra-individual variability in height achieved with the execution of the jumps. In spite of the fact that 7 subjects in the SJ and 8 in the CMJ showed a CV which was lower than 6%, the mean CV (SJ: $8.34 \pm 8.40\%$; CMJ: $6.29 \pm 4.78\%$) was higher than that obtained in previous studies by sports people without CP. Chelly et al. (2009) recorded a CV of 4.6% and 3.9% for the SJ and CMJ respectively (40). Ronnestad et al. (2008) obtained a CV of 3% in the CMJ (38) and Moir et al. (2008) a CV between 3.6% and 5.2% in a CMJ in young physically active subjects (49). Injuries in the basal ganglia (45), in the central nervous system and other cerebral structures involved in voluntary muscle contractions, as well as the manifestation of multiple involuntary extrapyramidal and dyskinesic movements (50) are considered to be the possible causes of the high intra-individual variability revealed in the present study. The differences in the CV among the soccer players could be due to a certain extent to the different impairments associated with each player with CP. This would explain the high CV shown by player J13 with regard to player J7.

With reference to the relation between the anthropometric characteristic, height of the soccer players with CP, and their jump capacity, a significant correlation was obtained between both variables ($r=0.67$, $p=0.01$), coinciding with a previous study (37) in which the height of the participants showed a significant correlation with the height of a CMJ ($r=0.36$; $p<0.01$). The height of the participants also showed a significant correlation with IE (Figure 3) and the BMI with the height obtained in the CMJ (Figure 1). To date no study had analyzed the relation between anthropometric characteristics and jump capacity in people with CP. As mentioned in previous studies (51-53), it would be interesting to carry out research to evaluate the influence of the height and BMI of the players in the selection and promotion of soccer players with CP.

Previous studies determined the existence of a high significant correlation between height obtained in the SJ and CMJ, due to the high specificity of both variables. Salaj and Marcovic (2011) obtained significant correlations between SJ and CMJ ($r=0.91$) in young students (32). Our study is the first one to determine that there also exists a high correlation between these two variables in elite footballers with CP.

Functional class did not show a significant relation with jump height. This fact

is worthy of note as, in spite of the functional classification being based on the type of impairment, joint mobility, walking and running function, coordination and function in the execution of technical aspects of the sports modality (25), this does not appear to be reflected in vertical jump capacity in elite soccer players with CP.

CONCLUSIONS

The results of the present study show that jump height obtained by elite soccer players with cerebral palsy in jumps with and without countermovement was lower than that obtained in soccer players without cerebral palsy, and lower than that obtained by young footballers. The effects of cerebral palsy are considered to be possible causes of the lesser strength of the lower limbs in soccer players with this condition. The significant correlations obtained between the height of the countermovement jump with the height of the soccer players and their body mass index suggest the need to make an in depth study of the relation between anthropometric and jump variables, and also point to the possible importance of these variables in the selection process of soccer players with cerebral palsy.

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