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Original article

Biomechanical differences of the technical gesture of the free half squat in professional and amateur bodybuilders

Diferencias biomecánicas del gesto técnico de la media sentadilla libre en físico-culturistas profesionales y amateur

Diferenças biomecânicas do gesto técnico do meio-francho livre em musculturistas profissionais e iniciantes

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ABSTRACT

The improvement of the sports technique is premised on comparing the values of the motor movement, this must be characterized to correct errors detected as part of the sports training management process. Emphasis is placed on highly technical sports, such as bodybuilding training. In this sense, the present research aimed to analyze the half-squat technique in professional and amateur bodybuilders as an empirical method (sport-specific measurement). The research is descriptive-explanatory of correlational order. Six variables of interest are correlated (X1: shoulder joint angle; X2: hip joint angle; X3: maximum speed reached; X4: maximum acceleration reached; X5: center of gravity in X; X6: center of gravity in Y). The means establish differences between independent groups, both in variable X1 (group 1: ≈66°; group 2: ≈70°; p=0.247), X2 (group 1: ≈73°; group 2: ≈86°; p=0.002), X3 (group 1: ≈1.03m/s; group 2:≈1.36m/s; p=0.017), X4 (group 1: ≈2.93m/s^2; group 2: ≈4.78m/s^2; p=0.011), X5 (group 1: ≈0.43m; group 2:≈0.65m; p=0.000), and X6 (group 1: ≈0.61m; group 2: ≈0.83m; p =0.000). Group 1 has a more effective technique, while the amateurs have less efficiency in biomechanical movement due to their inexperience, high values are shown in speed and acceleration, movement angles such as hip angles are included.

Keywords: Biomechanics; Half squat; Bodybuilders; Professionals; Amateurs.

RESUMEN

El perfeccionamiento de la técnica deportiva tiene como premisa comparar los valores del movimiento motriz, esta debe ser caracterizada para corregir errores detectados como parte del proceso de dirección del entrenamiento deportivo. Se pone énfasis en los deportes eminentemente técnicos, como es el caso del entrenamiento del fisiculturismo. En tal sentido, la presente investigación tuvo como objetivo analizar la técnica de la media sentadilla en fisiculturistas profesionales y amateurs como método empírico (medición específica del deporte). La investigación es descriptiva-explicativa de orden correlacional. Se correlacionan seis variables de interés (X1: ángulo de la articulación del hombro; X2: ángulo de la articulación de la cadera; X3: Velocidad máxima alcanzada; X4: aceleración máxima alcanzada; X5: centro de gravedad en X; X6: centro de gravedad en Y). Las medias establecen diferencias entre grupos independientes, tanto en la variable X1 (Grupo 1: ≈66°; grupo 2: H"70°; p=0.247), la X2 (grupo 1: ≈73°; grupo 2: ≈86°; p=0.002), La X3 (grupo 1:≈1.03m/s; grupo 2: ≈1.36m/s; p=0.017), la X4 (grupo 1: ≈2.93m/s^2; grupo 2: ≈4.78m/s^2; p=0.011), la X5 (grupo 1: ≈0.43m; grupo 2: ≈0.65m; p=0.000), y la X6 (grupo 1: ≈0.61m; grupo 2: ≈0.83m; p=0.000). El grupo 1 posee una técnica más efectiva, mientras que los amateurs poseen menor eficiencia en el movimiento biomecánico dada su inexperiencia, se muestran valores altos en velocidad y aceleración, se incluyen ángulos de movimiento como el de cadera.

Palabras clave: Biomecánica; Media sentadilla; físico-culturistas; Profesionales; Amateurs.

RESUMO

A melhoria da técnica desportiva baseia-se na premissa de comparar os valores do movimento motor, que deve ser caracterizada a fim de corrigir erros detectados como parte do processo de gestão do treino desportivo. A tónica é colocada no desporto

eminentemente técnico, como é o caso do treino de musculação. Neste sentido, o objectivo desta investigação era analisar a técnica de meio agachamento em musculturistas profissionais e iniciantes como um método empírico (medição específica do desporto). A investigação é descritiva-explicativa da ordem correlativa. Seis variáveis de interesse estão correlacionadas (X1: ângulo da articulação do ombro; X2: ângulo da articulação da anca; X3: velocidade máxima alcançada; X4: aceleração máxima alcançada; X5: centro de gravidade em X; X6: centro de gravidade em Y). Os meios estabelecem diferenças entre grupos independentes, tanto na variável X1 (grupo 1: ≈66°; grupo 2: ≈70°; p=0,247), a X2 (grupo 1: ≈73°; grupo 2: ≈86°; p=0,002), a X3 (grupo 1: ≈1. 03m/s; grupo 2: ≈1.36m/s; p=0.017), o X4 (grupo 1: ≈2.93m/s2; grupo 2: ≈4.78m/s2; p=0.011), o X5 (grupo 1: ≈0.43m; grupo 2: ≈0.65m; p=0.000), e o X6 (grupo 1: ≈0.61m; grupo 2: ≈0.83m; p=0.000). O grupo 1 tem uma técnica mais eficaz, enquanto os iniciantes têm uma eficiência de movimento biomecânico mais baixa devido à sua inexperiência, eles mostram menos eficiência no movimento biomecânico. Dada a sua inexperiência, são mostrados valores elevados em velocidade e aceleração, e são incluídos ângulos de movimento como o ângulo da anca.

Palavras-chave: Biomecânica; Meio agachamento; Musculturistas; Profissionais; Iniciantes.

INTRODUCTION

Within the world of training, the biomechanical analysis of each technical gesture is essential because the motor execution must be impeccable, emphasized in those eminently technical sports Goswami, (2020); Leon, *et al.,* (2016). For this reason, the analysis of the technical gesture in sports such as bodybuilding becomes important to optimize the sports technique and, therefore, improve the muscular planes to be trained that include muscular asymmetry and other associated variables Burdukiewicz, *et al.,* (2020). The bodybuilder, according to Sánchez-Rodríguez (2019), includes a series of exercises aimed at the excessive development of the muscles, which allow hypertrophies that must be harmonically developed by the muscle mass. It is considered in many cases as something extraordinary; the aim is to push the body to the limit with specialized training and sometimes with the use of legal or non-legal substances. These facilitate the growth and muscular enhancement of the organism (Díaz Cevallos, *et al.,* 2019; Schoenfeld, *et al.,* 2020; Montuori, *et al.,* 2021). The bodybuilder has well-defined features due to long periods of training and results in highly developed muscles. These elements are achieved with a great diet and excessive supplementation of carbohydrates, proteins and vitamins, which seek localized muscle hypertrophy as the main objective in each training session, in order to compete at the highest level, according to the category.

The squat is a multi-joint exercise in which the ankle, hip and knee work; there is a great muscular activation during the whole movement. On the other hand, Trujillo, *et al.,* (2020) point out that the muscles involved in the squat, to a large extent, are: quadriceps, glutes, calves and hamstrings. The execution of this exercise consists of the flexion and extension of the knee and the movement of the weight that is above the shoulders. Everett, (2020) classifies the squat in half squat and deep squat: for which they refer to the half squat to execution at an angle that does not exceed 90 degrees. In the deep squat, a variant is shown in which it is sought to sit on the calves at an inclination between 60 to 65 degrees.

The biomechanics of the half squat is a subject that is exposed to various points of view by training and health professionals. This arises as a result of the position of the feet, the angles of execution of the exercise, the speed and acceleration of the same, as well as the center of gravity of the performer. The half squat is an exercise that involves, to a large extent, muscle groups such as the quadriceps, abdomen, back, and glutes (Quevedo, *et al.,* 2021).

The half squat is an exercise widely used in the world of applied sports training (Morales, 2013). This originates because of the requirement in the majority of the musculoskeletal system to execute the motor movement. In many areas of biomechanics, specifically, and sports science, in general, the half squat is a well-studied movement. This is defined as a complex process as it is a movement that involves muscles of the lower body and joints such as the hips, ankles and knees. These are useful for completing numerous motor skills in various sports and as part of specialized exercises to enhance physical abilities such as strength (Beato, *et al.,* 2019; Shalmanov, Lukunina, 2020). The half squat is one of the most used daily movements by human beings, such as: sitting at work or in a means of transport, lifting a child or picking up an object from the floor, as well as lifting shopping bags and take them inside the home (Blanco-Díaz, Quitian-González, 2018).

A good execution of the technical gesture of the half squat is essential to avoid the risk of injury to athletes and amateurs. For this reason, the analysis of the technique and the motor gesture must be essential at the time of carrying out the exercise, taking as a methodological basis the results issued by professionals, an aspect that can serve as a theoretical basis to form effective intervention actions.

Therefore, this research aims to analyze the free half squat to improve technique in amateur athletes, taking professional bodybuilders as the main reference.

MATERIALS AND METHODS

For the present research, a total of 43 study subjects were taken into account, selected under an intentional, non-probabilistic sampling, which maintain their preparation in the specialized Training Zone center, located in the city of Quito, Ecuador. Two independent groups were created to establish the relevant comparisons: group 1 made up of professionals (20 subjects), and group 2 made up of amateurs (23 subjects), all male.

The inclusion criteria for the selection of professionals are:

- Have a high competitive level.
- Have been practicing the discipline for years.
- Do not have any type of disability that allows the athlete to perform the exercise.

The inclusion criteria for amateurs are the following:

- Do not maintain a long training path.
- Almost zero experience in training.

- Do not have any type of disability that allows to perform the exercise.

For the analysis of the variables, a video camera was used to obtain evidence of the performance of the technical gesture, which was subsequently analyzed with the Kinovea biomechanical analysis tool. This allowed to study some variables, such as:

- X1 Angle of the shoulder joint.
- X2 Angle of the hip joint.
- X3 Maximum speed reached.
- X4 Maximum acceleration reached.
- X5 Center of gravity at X.
- X6 Center of gravity at Y.

To carry out the study of the technical gesture of the half squat, each of the study subjects performed the exercise in the best possible way and thus be able to reach a specific analysis for the study. While, in the case of amateurs, they performed the execution of the half squat in the way they could do it. In both types of athletes, a 20-minute general and specific warm-up was previously performed. For this reason, the research strategy is of a descriptive-explanatory type of correlational order.

As there was no normal distribution of the data, a non-parametric correlational statistical study was applied to two independent samples. The latter is presented as the Mann-Whitney U Test ($p \leq 0.05$).

RESULTS AND DISCUSSION

Table 1 shows the data obtained in the six biomechanical variables analyzed in the half squat technique as part of the study required in professional bodybuilders (Table 1).

Table 1. - Biomechanical data of the half squat technique, professional bodybuilders

BODYBUILDERS	**x1**	**x2**	**x3**	**X4**	**x5**	**X6**
variables	Degrees		m/s	m/s2	m	m
1	83	75	0.85	3.53	0.75	0.86
2	58	68	0.42	1.79	0.56	0.63
3	66	73	0.72	1.79	0.36	0.42
4	76	62	0.81	2.04	0.35	0.41
5	58	63	1.28	2.97	0.39	0.56
6	76	74	0.8	1.85	0.37	0.68
7	68	77	0.99	3.1	0.24	0.53
8	52	77	1.85	5.22	0.48	0.7

9	63	54	0.98	3.47	0.45	0.69
10	55	53	1.2	5.12	0.44	0.79
11	54	74	0.77	1.63	0.44	0.67
12	63	77	0.83	1.58	0.41	0.63
13	73	89	0.88	1.54	0.41	0.66
14	70	86	1.01	4.28	0.39	0.68
15	60	79	1.04	3.56	0.43	0.6
16	74	70	1.24	2.6	0.46	0.59
17	65	78	0.48	1.39	0.41	0.35
18	71	76	1.71	4.22	0.4	0.42
19	68	79	1.23	3.93	0.5	0.74
20	72	77	1.57	2.94	0.45	0.5
□	**66.25**	**73.05**	**1,033**	**2.9275**	**0.4345**	**0.6055**

The means obtained by the professional bodybuilders are tabulated as part of the last row (Table 1), where an average is obtained in the variable "X1" of ≈66°. This is shown as the angle of the shoulder joint less than the average obtained in amateur bodybuilders who presented a≈70° (Table 2). On the other hand, the professional bodybuilders presented a mean in the variable "X2" of ≈73°, a mean in the variable "X3" of ≈1.03m/s, in the variable "X4" of ≈2.43m/s^2, a mean in the variable "X5" of ≈0.43m and a mean in the variable "X6" of ≈0.61m.

In the case of the results obtained with the six variables analyzed from amateur bodybuilders, table 2 shows their general tabulation.

Table 2. - Biomechanical data of the half squat technique, amateur bodybuilders

AMATEUR	**x1**	**x2**	**x3**	**X4**	**x5**	**X6**
variables	Degrees		m/s	m/s2	m	m
one	70	88	1.03	3.47	0.9	0.91
two	56	85	1.71	6.11	one	0.79
3	43	76	1.33	5.92	0.44	0.63
4	47	87	1.12	2.89	0.4	0.83
5	91	99	1.17	5.39	0.42	0.99
6	58	94	1.19	4.66	0.46	0.81
7	85	68	2.19	9.38	0.48	0.85
8	51	81	1.52	3.22	0.43	0.78
9	83	103	1.92	8.96	0.56	1.21

10	75	88	0.98	2.94	0.56	0.86
11	95	112	1.66	8.19	0.53	1.24
12	76	80	1.76	3.83	0.96	0.58
13	91	97	1.22	5.65	0.56	0.8
14	68	65	0.62	1.66	0.41	0.35
15	63	86	0.78	2.05	0.53	0.66
16	41	74	1.89	4.74	0.95	0.86
17	60	107	1.77	5.82	0.7	0.85
18	80	82	1.02	2.87	0.74	0.87
19	70	59	1.12	2.43	0.79	0.81
20	79	79	1.59	8.69	0.79	0.83
21	75	90	1.26	3.37	0.85	1.03
22	71	106	0.69	1.18	0.78	0.95
	80	72	1.67	6.51	0.76	0.71
□	**69.91**	**86.00**	**1.36**	**4.78**	**0.65**	**0.83**

As in the previous table, the means obtained are shown in the last row of table 2, where the mean obtained in the variable "X1" was H"70°. Here, the average presented by the professionals is presented to a greater degree, although no significant differences were found (p=0.247). This is the case as calculated with the Mann-Whitney U Test (Table 3). In this sense, it is determined that there is no variation in these values, and that the amateurs maintain a correct angulation in the position of the shoulders. It was developed like this, when executing and positioning the shoulder during the half squat exercise.

On the other hand, the variable "X2" obtains a mean of ≈86°; this is the angle of the hip joint greater than that presented by professionals; significant differences prevail (p=0.002). For the analysis of the second point, the position angle was referenced to the hip as the main point and the inclination that the analysis program showed for both population groups. This denotes a very different execution of the half squat exercise; this situation is due, to a large extent, to the lack of technique and to the lesser practice of physical exercise. This exercise provides a greater or lesser inclination of the hip joint, which can be harmful in the long term if the technique and motor position of the movement are not corrected. This is the same for the distance of the feet as for the position of the bar, the weight and, of course, the inclination of the hip.

The variable "X3" presented an average of 1.36 m/s, being the maximum speed reached less than that presented in group 1, with significant differences in favor of the group of professional bodybuilders (p=0.017). In the case of the variable "X4", the average presented by the amateur bodybuilders was established at 4.78m/s^2, with the maximum acceleration being much higher than that established in the professional bodybuilders, with a significant difference (p=0.011).

For the analysis of the two aforementioned variables, in the speed and maximum acceleration reached within the execution of the half squat, a great variation can be noted, the values of the ranges (Table 3). This variation determined average values of 17.10 for the speed ranges, while the amateurs increased these values to 26.26. In this, a higher value is shown than that of professional athletes, while the same thing happened in the maximum acceleration of the half squat exercise. The data that the professional bodybuilders showed was 16.75 and the data of the amateurs amounted to 26.57.

The great variation between both population groups, to a large extent, is due to the speed of execution of the exercise in amateurs, due to the fact that they do not control the performance of the half squat, in many cases without showing a good technique and control of the movement weight on the bar.

For the case of the variable "X5", the mean established in group 2 was 0.65m, greater than that established in group 1; significant differences (p=0.000) prevail in the center of gravity of the X axis, as well as in the center of gravity in the Y axis (p=0.000). In this case, a mean of 0.83m was established in group 2, higher than that established in group 1.

In the center of gravity analysis, the average values as well as the ranges (Table 3) and (Table 4) vary in both the X-axis and the Y-axis. This variation of the values in the center of gravity is caused by the differences in height and weight in each participant and, to a large extent, due to the execution they showed in performing the technical gesture of the half squat.

All the correlations described, as well as the ranges determined by the Mann-Whitney U, are shown as part of Table 3 (Table 4).

Table 3.- Results of the Mann-Whitney U Test in the biomechanical variables of each independent group

Ranks				
Data	Group	N	Rangep romeo	sum of ranks
Data: angle shoulder	Physical bodybuilders	20	19.63	392.50
	amateur		24.07	553.50
	Total	43		
Data Angle Hip	Physical bodybuilders	20	15.53	310.50
	amateur		27.63	635.50
	Total	43		
Data velocity maximum	Physical bodybuilders	20	17.10	342.00
	amateur		26.26	604.00
	Total	43		
Data acceleration maximum	Physical bodybuilders	20	16.75	335.00

	amateur		26.57	611.00
	Total	43		
Data center of gravity X	Physical bodybuilders	20	14.05	281.00
	amateur		28.91	665.00
	Total	43		
Data Center gravity Y	Physical bodybuilders	20	13.78	275.50
	amateur		29.15	670.50
	Total	43		

Table 4. - Group variable: Group

	Test statistics [to] _					
	Data angle shoulder	Data angle hip	Data speed maximum	Data acceleration maximum	Data center of gravity X	Data center of gravity Y
Mann–Whitney U	182,500	100,500	132,000	125,000	71,000	65,500
W for Wilcoxon	392,500	310,500	342,000	335,000	281,000	275,500
Z	-1,158	-3,156	-2,386	-2,557	-3,876	-4,008
Asymptotic sig. (bilateral)	.247	.002	.017	.011	,000	,000

Characterizing technical movements from a biomechanical point of view is a necessity for the sciences of physical activity and sport. Here, various comparisons are made that lead to analyzes that explain important details for the sports training management process (Andrade, *et al.,* 2019). In the case of the study of the half squat, the literature shows numerous works directly related to specific sports such as the triple jump (Ródenas, *et al.,* 2020). Its effects on specific performance, while various analyzes focus on related variables such as the range of motion in the squat exercise on neuromuscular and functional adaptations (Martínez-Cava, Morán-Navarro, 2019). The incidence of muscle mass in the lower limbs indicates the maximum repetition in the half squat. In any case, the analysis of the motor movement studied is essential to perfect the sports technique; this serves as a theoretical and methodological basis for error correction and, therefore, for specialized motor improvement.

As an alternative proposal, it is recommended to design a guide on error correction for the execution of the half squat exercise in amateur bodybuilders; as well as greater attention to sports technique in general by coaches and physical assistants.

CONCLUSIONS

The correct execution of the exercise by the bodybuilder complied with the requirements established within the bibliographic compilation; an effective technique is obtained and mainly avoids problems such as injuries.

In the execution of the technical gesture in amateur bodybuilders, a lower efficiency in the biomechanical movement of the half squat was determined. This was possible due to the lack of experience in performing the studied movement. High values are shown in the parameters studied, such as: speed and acceleration; angles of movement are included and the angle of the hip is emphasized.

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