IS IT NECESSARY TO NORMALIZE JUMP TEST RESULTS TO ANTHROPOMETRIC PARAMETERS?

Cristian Rojas-Reyes[1], Esteban Aedo-Muñoz[1,2,4], Amaya Prat-Luri[3], Ciro José Brito[4] & Bianca Miarka[4,5]

Department of Physical Education, Universidad Metropolitana de Ciencias de la Educación, Santiago, Chile[1]
Physical Activity, Sport and Health Sciences Laboratory, Universidad de Santiago, Santiago, Chile[2]
Sport Research Centre, Miguel Hernández University, Spain[3]
Postgraduate Program in Physical Education. Physical Education Department. Federal University of Juiz de Fora, Brazil[4]
Postgraduate Program in Physical Education, School of Physical Education and Sports, Department of Fights. Federal University of Rio de Janeiro[5]

The purpose of the present study was to analyse the relationship of different normalization methods in the jump performance, obtained from a digital application (My Jump 2 ®). 189 young women made up the sample. Each of them had to perform three attempts of a bilateral countermovement jump (CMJ) in front of a mobile device. The jump height (JH) and power (P) were the main results, which were processed to normalize them. The JH was normalized to height (JH/H) and to leg length (JH/LL). P was normalized to body mass (RP), while force values were divided by the time of jump to get the Explosive Index of Strength (EIS). The results showed a good association and poor prediction between the variables JH and P, not so between JH and EIS, where no significant relationship was observed. However, a strong relationship was observed between JH / LL and RP ($r = 0.801$; $r2 = 0.641$; $p < 0.05$). The results indicate that this mobile application shows a good association between its variables, however, it is necessary to apply jump height and power normalization procedures to increase the relationship level. Regarding the EIS values, it is necessary to use the force and jump time variables individually, to relate them to the jump height. Under this analysis it can be determined that the power level of the lower limbs can be useful as an indicator of the jump height. Researchers and coaches should include these types of procedures to further refine vertical jump performance assessments.

KEYWORDS: Smartphone app, vertical jump, biomechanics.

INTRODUCTION: Interest towards the employment of technology in sport, exercise, health and physical education contexts has been lately growing, aiming the improvement of physical exercise assessment on these different scenarios (Wintle, 2019). Since assessment remains essential, because of the affordability provided by electronic devices such as smartphones or tablets, they are more and more used in order to better control the effects evoked by exercise. This allows a more objective assessment of the capacities involved in the different actions performed (Barahona, 2019).

From the wide functional capacities commonly evaluated, vertical jump has been targeted as an outcome of high interest, since it has been related to performance parameters such as power or strength (Sozbir, 2016; Stone et al., 2003). In this sense, digital applications such as *My Vertical®, My Jump®* and *My Jump 2®* have been developed and already validated for the assessment of jump performance (Gallardo-Fuentes et al., 2016) by means of video assessment of different jump tests (Sharp, Cronin, & Neville, 2019). The availability of these type of application remains important, since they are low-cost tools that provide a reliable assessment of capacities that are associated with the performance of each person. This help to control the further progression of athletes, optimizing training programs in a more objective and quantitative approach. There is an extensive variety of jump test depending on the biomechanical and physiological characteristics involved, from which the CMJ is one of the most commonly employed (Rago et al., 2018). The CMJ has been proposed has an important marker of performance in several sports (Tillin & Folland, 2014), probably because of the shortening-stretching cycle present in many sport actions. The outcome most frequently assessed is jump height, mainly due to its ease of measurement. It is reasonable to expect that people with different physical condition cannot reach the same result, since their capacities differ from each other. On this way, jump height has been barely normalized to any anthropometric parameter, hindering the comparison of jump performance. Thus, it is necessary to normalize results to at least an anthropometric characteristic in order to obtain results more precise and comparable among athletes (Pérez-Soriano & Llana Belloch, 2015).

In the context of jump performance, power plays a determinant role in the assessment of the subject's neuromuscular capacity, along with other variables such as force, flight time, velocity and jump height, that must be measured and processed appropriately (Linthorne, 2020). The management of these variables determines the validity that they can acquire depending on the specific use required (McGhie, Østerås, Ettema, Paulsen & Sandbakk, 2018). In this sense, power seems to be a good predictor of vertical jump performance, and vice versa, proving necessary to establish the level of relationship that exist between the jump height normalized and power.

METHODS: 189 young physically active females (age: 17,18±0,72 years; mass: 54,27±8,02 kg; height: 167,33±7,60 cm) participated in the study. A 7-min specific warm-up was performed prior to jump testing (Tobin & Delahunt, 2014). Jump testing consisted on three repetitions with 2-minutes rest between each trial (Lockie et al., 2017). Jumps were registered through My Jump 2® application integrated in an Ipad Air 2 device. The protocol registration is advertised elsewhere (Balsalobre-Fernández, Glaister, & Lockey, 2015). Anthropometric measurements were made one hour before warm-up.

The main outcomes analysed were jump height (JH) and power (P). Both of them were then normalized to height, leg length and mass, obtaining the subsequent outcomes: jump height normalized to participant's height (JH/H), jump height normalized to participant's dominant leg length (JH/LL), power normalized to participant's mass (RP). The dominant leg length was measured by the tape measure technique (Neely, Wallmann & Backus, 2013). The subjects were measured in the supine position with the hip, knee and foot in extension, taking the greater trochanter and the most distal phalanx of the thumb of the foot as reference point (Balsalobre-Fernández, Glaister, & Lockey, 2015). Moreover, the explosive index of strength (EIS) was calculated from the force values divided by jump's time (Centeno-Prada, López, & Naranjo-Orellana, 2015).

Statistical analysis was performed with GraphPad (8.0). Mean and standard deviation was calculated for JH, JH/H and JH/LL. Raw jump height and normalized jump height were analysed respect to power, relative power and EIS. Correlation (r) and regression analysis (r^2) were performed to analyse the association and level of prediction respectively. Statistical significance level was set at $p<0,05$.

RESULTS: Descriptive, correlation and regression CMJ results are advertised in table 1. All normalization parameters showed moderate relationship with power, obtaining similar correlation values ($0,539 \leq r \leq 0,595$). The association increased when power was normalized to mass (RP), wherein leg length was the anthropometric parameter that provided the highest correlation (r=0,801). On the other hand, faint association was observed for JH, JH/H and JH/LL respect to EIS. Regarding regression JH/LL had the strongest level of prediction followed by JH (r^2=0,641 and 0,553 respectively).

Table 1: Correlation and regression results for jump performance outcomes.

		Power (1126,16±2,15 W)		Relative Power (20,9±3,66 W/Kg)		Explosive Index of Strength (2056,75±389,89)	
	(mean±SD)	*r*	r^2	*r*	r^2	*r*	r^2
JH	(27,12±4,62cm)	0,595*	0,354	0,743**	0,553*	-0,222	0,000068
JH/H	(0,16±0,03cm)	0,539*	0,00052	0,706**	0,003	-0,244	0,013
JH/LL	(0,28±0,05cm)	0,529*	0,280	0,801**	0,641**	-0,189	0,00088

*p<0.05; **p<0,01

SD: Standard Deviation – JH: Jump Height – H: Height – LL: Leg Length.

DISCUSSION: The purpose of the present study was to analyse the relationship of anthropometric parameters with jump performance parameters of CMJ obtained with *My Jump 2®* app. The results obtained support the former evidence, which claimed for the need of normalize jump height to anthropometric parameters (Niwa, Perren, & Hattori, 1992; Markovic & Jaric, 2007). In agreement with Moir et al. (2008), the results of this study also found differences between raw data and normalized data, where the association and prediction levels of jump height and power normalized with anthropometric parameters increased respect to raw data.

On the other hand, EIS did not showed any relationship when normalized to JH, JH/H and JH/LL; probably this resides in the fact that strength and velocity should be independently related to JH; also, power appears to be a strong indicator for the jump performance, thus, the need of improve the measures on this direction, it becomes increasingly important as suggested previously dal Pupo (2012). Hammami et al. (2019) reported significant relationships between stature, lower limb length, ratio of lower limb length/stature and sitting height/stature to the jump performance of volleyball players, also demonstrated a close relationship between anthropometric data, sprinting, jumping, anaerobic and endurance performance.

Likewise, Ugarkovic et al. (2002) found a weak correlation between isometric strength and jump testing, so as for the anthropometric parameters that they evaluated. In this sense, it is likely that the height of subjects but overall the leg length, is enough to normalize the jump height. However, if other outcomes involved in jump performance like power are analysed, it seems to be necessary to normalize it to each subject mass (Pietraszewski & Rutkowska-Kucharska, 2011). This probably resides in the fact of specificity, since height or leg length are anatomic parameters, especially leg length as this method is more related to jump height because it is part of the take-off phase on the vertical jump, either CMJ, SJ or DJ, therefore it makes it more sensitive to the height reached. On the other hand, mass parameters as weight, are more related to power or strength outcomes.

CONCLUSION: A strong relationship among anthropometric parameters and jump performance parameters was observed in the present study. This finding indicates that when the jump height was normalized to leg length and power normalized to individual mass, the results become more accurate, enhancing measurement processes through this type of applications. Moreover, although many normalization parameters are available, it seems that they have to be specific depending on the performance parameters to analyze. Sport science professionals and coaches should include this procedures to their works as the normalization methods improve the data manages, increasing reliability of results.

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REFERENCES

Balsalobre-Fernández, C., Glaister, M., & Lockey, R. A. (2015). The validity and reliability of an iPhone app for measuring vertical jump performance. *Journal of Sports Sciences*, *33*(15), 1574–1579. https://doi.org/10.1080/02640414.2014.996184

Barahona, J. (2019). Retos y oportunidades de la tecnología móvil en la educación física (Challenges and opportunities of mobile technology in physical education). Retos: Nuevas Tendencias En Educación Física, Deporte y Recreación, 37(July 2019), 763--773. Retrieved from https://recyt.fecyt.es/index.php/retos/article/view/68851/45787

Centeno-Prada, R., López, C., & Naranjo-Orellana, J. (2015). Jump percentile: a proposal for evaluation of high level sportsmen. *The Journal of Sports Medicine and Physical Fitness*, *147*(2), 135–140. https://doi.org/10.13140/RG.2.1.5129.4169

dal Pupo, J., Detanico, D., & dos Santos, S. G. (2012). Parâmetros cinéticos determinantes do desempenho nos saltos verticais. *Revista Brasileira de Cineantropometria e Desempenho Humano*, *14*(1), 41–51. https://doi.org/10.5007/1980-0037.2012v14n1p41

Gallardo-Fuentes, F., Gallardo-Fuentes, J., Ramírez-Campillo, R., Balsalobre-Fernández, C., Martínez, C., Caniuqueo, A., … Izquierdo, M. (2016). Intersession and intrasession reliability and validity of the my jump app for measuring different jump actions in trained male and female athletes. *Journal of Strength and Conditioning Research*, *30*(7), 2049–2056. https://doi.org/10.1519/JSC.0000000000001304

Hammami M, Hermassi S, Gaamouri N, Aloui G, Ardigò LP. Field Tests of Performance and Their Relationship to Age and Anthropometric Parameters in Adolescent Handball Players. Front Physiol. 2019;10(September):1–12.

Linthorne N. The correlation between jump height and mechanical power in a countermovement jump is artificially inflated. Sport Biomech. 2020;1–19.

Lockie, R., Coburn, J., Tran, T., Brown, L., Watkins, C., Barrilas, S., … Dobbs, I. (2017). Determination of Vertical Jump As a Measure of Neuromuscular Readiness and Fatigue. *The Journal of Strength and Conditioning Research*, *31*(12), 3305–3310. https://doi.org/10.1519/JSC.0000000000002231

McGhie D, Østerås S, Ettema G, Paulsen G, Sandbakk O. Strength Determinants of Jump Height in the Jump Throw Movement in Women Handball Players. J Strength Cond Res. 2018 Jun 1. https://doi.org/10.1519/JSC.0000000000002684

Markovic, G., & Jaric, S. (2007). Is vertical jump height a body size-independent measure of muscle power? Journal of Sports Sciences, 25(12), 1355–1363. https://doi.org/10.1080/02640410601021713

Moir, G. L. (2008). Three Different Methods of Calculating Vertical Jump Height from Force Platform Data in Men and Women. Measurement in Physical Education and Exercise Science, 12(4), 207–218. https://doi.org/10.1080/10913670802349766

Neelly K, Wallmann HW, Backus CJ. Validity of measuring leg length with a tape measure compared to a computed tomography scan. Physiother Theory Pract. 2013;29(6):487–92.

Niwa, S., Perren, S., & Hattori, T. (1992). *Biomechanics in Orthopedics* (S.-V. Tokyo, ed.). Tokio: Springer Science & Business Media.

Pérez-Soriano, P., & Llana Belloch, S. (2015). Biomecánica básica aplicada a la actividad física y el deporte. In Paidotribo. Barcelona: Paidotribo.

Pietraszewski B, Rutkowska-Kucharska A. Relative power of lower limbs in drop jump. Acta Bioeng Biomech / Wrocław Univ Technol. 2011;13:13–8.

Rago, V., Brito, J., Figueiredo, P., Carvalho, T., Fernandes, T., Fonseca, P., & Rebelo, A. (2018). Countermovement Jump Analysis Using Different Portable Devices: Implications for Field Testing. *Sports (Basel, Switzerland)*, *6*(3), 91. https://doi.org/10.3390/sports6030091

Sharp, A. P., Cronin, J. B., & Neville, J. (2019). Using Smartphones for Jump Diagnostics. *Strength and Conditioning Journal*, *41*(5), 96–107. https://doi.org/10.1519/ssc.0000000000000472

Sozbir, K. (2016). Effects of 6-Week Plyometric Training on Vertical Jump Performance and Muscle Activation of Lower Extremity Muscles. The Sport Journal, 17(March), 1–18. Retrieved from https://thesportjournal.org/article/effects-of-6-week-plyometric-training-on-vertical-jump-performance-and-muscle-activation-of-lower-extremity-muscles/

Stone, M. H., O'Bryant, H. S., McCoy, L., Coglianese, R., Lehmkuhl, M., & Schilling, B. (2003). Power and maximum strength relationships during performance of dynamic and static weighted jumps. *Journal of Strength and Conditioning Research*, *17*(1), 140–147.

Tillin, N. A., & Folland, J. P. (2014). Maximal and explosive strength training elicit distinct neuromuscular adaptations, specific to the training stimulus. *European Journal of Applied Physiology*, *114*(2), 365–374. https://doi.org/10.1007/s00421-013-2781-x

Tobin, D. P., & Delahunt, E. (2014). The acute effect of a plyometric stimulus on jump performance in professional rugby players. *Journal of Strength and Conditioning Research*, *28*(2), 367–372. https://doi.org/10.1519/JSC.0b013e318299a214

Ugarkovic, D., Matavulk, D., Kukolj, M., & Jaric, S. (2002). Standard anthropometric, body composition and strength variables as predictors of jumping performance in elite junior athletes. *Journal of Strength and Conditioning Research*, 16(2), 227–230.

Wintle, J. (2019). Digital technology in physical education: global perspectives. *Sport, Education and Society*, *24*(6), 665–667. https://doi.org/10.1080/13573322.2019.1618103