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Brazilian Journal of Physical Therapy

https://www.journals.elsevier.com/brazilian-journal-of-physical-therapy

LETTER TO THE EDITOR

The (un)standardized use of handheld dynamometers on the evaluation of muscle force output

The measurement of muscle force output is a *sine qua non* of physical performance evaluation in research and clinical environments. The isokinetic dynamometer is the gold standard[1,2,3] as it provides a complete profile of muscle force output, but high cost and lack of portability severely restrict its application. In comparison, the handheld dynamometer (HHD) has been proposed as a low-cost and portable alternative for measuring muscle performance in the clinical setting.[3] However, the ease of HHD may lead to misapplication and potentially misinterpretation.

HHDs consist of electronic and/or mechanic force sensors that need to be positioned perpendicular to the tested limb for accurate measurements. The tested individual performs a maximal effort while the tester resists applying an opposing force of equal magnitude to prevent movement. The measured force depends on the distance between the point of application of the dynamometer and the joint's center of rotation. For a given torque generation, a lower force is measured when the dynamometer is applied further away from the joint. The torque, or moment of force, is recognized by the Greek letter *tau* (τ) and expressed by the following equation:

$$\tau = \vec{F} \times \bar{d_{\perp}}$$

where $\vec{F}$ is the applied tester resistance force and $\bar{d_{\perp}}$ is the perpendicular distance from the location where the force is applied to the evaluated joint. Torque is expressed in units of Newton.meter (N.m), and is the standard measure to assess muscle performance with isokinetic dynamometers.

Previous studies have proposed standard protocols for HHDs,[4] in which the device should be placed in a defined distance from a target anatomical reference. However, using an anatomical reference may lead to different readouts depending on the variations in the lever arm of individuals of various sizes. Thus, to consider the raw HHD output as the ''muscle force'' is misleading, as the measurement depends on the perpendicular distance between the dynamometer and the evaluated joint. Such misapplication can be identified in a recent study from Daloia et al.[5] who reported the isometric muscle strength for four joints (shoulder, elbow, knee, and ankle) of boys and girls aged between 5 and 15 years. The authors suggested that their results can be used as reference for muscle strength in the Latin American population. However, without providing the results based on torque values, these measurements are not comparable to any population other than the studies group. Interestingly, Daloia et al.[5] cited four studies that reinforce the need to consider torque estimation as a standard of measurements.[6,7,8] Eek et al.[6] suggested that ''to obtain comparable measurements one must either put the device at the same distance from the joint or measure the distance (lever arm) and calculate the torque (force by distance)''. Eek et al.[6] also suggest that ''In growing children, this [limb length] leads to a change in distance from the joint center, which makes the latter method with calculation of torque more suitable''. Conversely, we also identified several studies that employed HHDs to measure force but without estimation of muscle torque, [8,9,10] indicating a possible misunderstanding of basic biomechanics concepts.

Therefore, this letter highlights the need for considering torque as the absolute, suitable estimate of muscle performance when using HHDs.

Acknowledgments

The authors thank Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES): - Finance Code 001.; and V.H.S. is funded by the Jane & Aatos Erkko Foundation.

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https://doi.org/10.1016/j.bjpt.2019.10.004

Response to the letter to the Editor entitled, ''The (un)standardized use of handheld dynamometers on the evaluation of muscle force output.''

The authors allude to a possible misconception of basic biomechanics, when muscle strength evaluation does not consider the lever arm distance to calculate torque as the main muscle force output.[1] They cite our article from 2018 entitled, ''Isometric muscle strength in children and adolescents using handheld dynamometry: reliability and normative data for the Brazilian population'', as an example of using such misconception.[2]

We agree that torque values allow for better individual comparisons because the measurement includes consideration of the individuals' lever arms. Although this is the correct concept for muscle strength assessment, articles in the literature show some ''flexibility'' regarding the presentation and use of strength data. The following are a few papers that have used the handheld dynamometer (HHD) in different clinical and methodological contexts for children and adolescents. Beenakker et al.[3] and Ervin et al.[4] published normative values in units of force for typical children and adolescents. McLaine et al.[5] similarly reported weight-normalized force values for adolescent swimmers. A recent normative study by McKay et al.,[6] using HHD with children and adolescents, transformed the force measured in N into torque values in Nm and provided an anthropometric correction table. Recent clinical studies about chronic diseases, in children and adolescents, provide force values: Bos et al.,[7] Kennedy et al.,[8] as well as force values transformed into Z scores: Burns et al.,[9] Lin et al.[10] While Hébert et al.[11] provide muscle torque, obtained from measured force and lever arm analysis.

It is challenging to work with children and adolescents and to perform muscle strength assessments. Thus, instruments such as the HHD are reliable, even when testing larger muscles. The primary aim of our study was to test the reliability of the HHD in typical children and adolescents. The use of absolute muscle strength data meets the needs of the paper. Moreover, the authors were careful to refer to muscle strength data and never muscle torque. Second, the paper presented the data considering differences in age groups. Participants' age-appropriate body mass index (BMI) was assumed, based on the absence of statistical difference between anthropometric data within a specific age. This ensures that muscle strength data are representative of a given age. Unfortunately, we did not highlight that muscle torque data would technically represent the best output variable.

While our data present isometric muscle force data and not muscle torque data, we remain convinced of the study's contribution to the field of Physical Therapy.

Funding

This work was supported by the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) [grant number 2014/23232-7], Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (Capes) and Fundação de Apoio ao Ensino, Pesquisa e Assistência do Hospital das Clínicas da Faculdade de Medicina de Ribeirão Preto da Universidade de São Paulo (FAEPA). ACM-S is a research productivity grant recipient from Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) [grant number 309058/2018-0].

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