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LETTER TO THE EDITOR

Letter to the editor concerning the article "Bar velocities capable of optimising the muscle power in strength-power exercises" by Loturco, Pereira, Abad, Tabares, Moraes, Kobal, Kitamura & Nakamura (2017)

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ABSTRACT
Loturco and co-workers (2017) recently published data in the Journal of Sports Sciences to present the optimum loading magnitudes regarding the maximization of the "mean propulsive power" of the leg and arm muscles. Among the most important findings were that (1) the recorded power in the squat and squat jump exercises was markedly low, (2) the optimum external load that maximized the power in the same exercises was close to 100% of body weight, while (3) the ballistic bench press throw revealed smaller power than the regular bench press typically performed with relatively low level of muscle activation towards the end of the propulsive lifting phase. The findings are either counter-intuitive, or contradict the literature findings, or both, and we believe that they originate from apparent methodological flaws. The first one is neglecting the force acting against the body segments moved together with the external load that is particularly high in squat exercises. The second one is an erroneous calculation of the propulsive phase that included a part of the bar's flight time. Both of these methodological flaws are frequent in the literature and could be associated with the improper use and calculation of variables when utilizing linear position transducers.

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In their recent study Loturco, Pereira, Abad, Tabares, Moraes, Kobal, Kitamura & Nakamura (Loturco et al., 2017) manipulated external load in squat and bench press exercises performed both in the traditional (half squat and bench press lifting) and ballistic fashion (squat jump and bench press throw, respectively). The specific aims were to test whether (1) the bar velocity is a more precise indicator (than the related maximum strength measurements) of the optimum power loads; (2) there are fixed mean propulsive velocities (MPV) capable of maximising the respective mean propulsive power (MPP) during the execution of the four investigated exercises; and (3) there are differences in the MPP and MPV (at the optimum power zones) between the ballistic and traditional exercises. The assessment of lifting velocity was exclusively based on the recording of a linear position transducer attached to the bar, while the acting force was calculated from the weight and inertia of the lifted weights. Mean values of velocity and power (i.e., MPV and MPP, respectively) were thereafter calculated over the propulsive phase of the lifting.

The main motivation for this Letter to the Editor comes from 3 findings that are either in contradiction with literature data, or counterintuitive, or both. The first one is a recorded low-level MPP particularly in squat exercises. The second one is that the optimum external load that maximizes MPP could be close to the subjects' body weight in the half squat and squat jump. The third one is that the bench press throw provides lower MPP than the traditional bench press. The same problems exist with the remaining tested exercises, but the associated error magnitudes should be much lower. Within the further text we will provide details about the methodological flaws that are mainly responsible for such findings, as well as explain that such problems often emerge as a result of incorrect calculation of the data recorded by linear position transducers.

Regarding the first questionable finding, note that according to the laws of physics, the systems are moved only by the action of external forces. The system here consists of the moved body segments and the added mass of external weights. Roughly, for the bench press and bench throw exercises the moved segments are 2 arms (i.e., muscle action exerts the external force at the contact of the upper trunk and shoulders with the bench), while for the half squat and squat jump virtually all body segments are moved with the added weights due to the action of leg muscle exerting the ground reaction force (Lake, Lauder, & Smith, 2012). According to the standard Dempster's model (Dempster, 1955), the percentage of body mass moved with the bar in the bench press and bench throw is approximately 10%, while for the half squat and squat jump is close to 100% of body weight. Misfortunately, Loturco et al. (2017) did not consider the contribution of the body mass to the lifted mass. Therefore, when assessing the muscle power output (i.e., MPP) the authors markedly underestimated the total load that had to be overcome by muscle action, particularly in the squat exercises. The

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problem has been already recognized in literature (Cormie, McBride, & McCaulley, 2007a; Jaric & Markovic, 2013; Lake et al., 2012; Rambaud, Rahmani, Moyen, & Bourdin, 2008). Note that the underestimation was relatively higher for lighter external loads applied. The final result was that MPP of rugby players appeared to be only half of the same values recorded in non-trained individuals (Cuk et al., 2014), as well as that MPP of powerful leg muscles was only slightly above the MPP of arm muscles.

Note that the presented calculation of the percentage of body mass contributing in the studied exercises is only an approximate one. For example, according to Lake et al. (2012) the vertical displacement of the feet and to certain extent lower legs is practically non-existent in the squat exercise and, therefore, some authors consider that only 88% of body mass contributes to the total load in squat exercises (Cuk et al., 2014; Nuzzo et al., 2010). Regarding the bench press, the centre of mass of the arm segments moves at about half velocity of the bar and, therefore, the participating arm mass should be halved (Sreckovic et al., 2015). A similar phenomenon appears in squat exercises where the system's centre of mass (i.e., the body segments plus external loads) moves at a somewhat lower velocity than the bar (García-Ramos et al., 2016; Lake et al., 2012), but the marked underestimation of the total load in the squat exercises still remains.

The second questionable finding is the altered load-power relationship that also originates from neglecting the role of body mass in the tested exercises. Authors reported that the external load that corresponds to 80–100% of body mass maximizes the muscle power output in squat exercises and, therefore, represents the optimum training load to be applied. However, there is a body of evidence that the optimum loading in vertical jumps is close to 0% of body weight (i.e., no loading applied), under the condition that the moved body mass segments are correctly included in the calculation of the total acting load (Cormie, McBride, & McCaulley, 2007b; Jaric & Markovic, 2009, 2013; Nuzzo et al., 2010). McBride and co-workers clearly demonstrated the difference between the optimum load when the body mass is (i.e., close to 0% of body mass) and is not included in the power calculation (close to the maximum external load; McBride, Haines, & Kirby, 2011). The same finding could be even independent of the subject's fitness level (Jaric & Markovic, 2013; Pazin, Berjan, Nedeljkovic, Markovic, & Jaric, 2013). From this perspective, it is not surprising that the jumping training conducted without external load (Vissing et al., 2008) or even with "negative load" (Markovic, Vuk, & Jaric, 2011) could be more beneficial for gaining the muscle power output.

The third questionable finding of the study is that MPP is higher in the traditional bench press than in the ballistic bench throws that clearly contradict literature findings (Frost, Cronin, & Newton, 2008; Garcia-Ramos, Jaric, Padial, & Feriche, 2016). Note that the later exercise maintains the maximum muscle activation over the entire movement range since it does not voluntarily slow down the bar velocity close to the end of the propulsive phase. However, the authors calculated the propulsive phase duration as the period of the bar velocity being positive. That method applied to the bench throws (but not the bench press) inevitably included a part of the bar's flight phase where the contact between the hands and bar ceased to exist, while the bar still continued to move upward. As a result, the calculation of MPP included a non-negligible time interval when the muscle power output was virtually zero. This inevitably reduced the MPP magnitude in bench throws, but not in the bench press where the flight phase does not exist. Therefore, we believe that the authors' statement that "possibly, the ballistic condition does not maximise the 'maximum power production' strength-power exercises performed using the upper extremities" is not only counter-intuitive, but also based on a result of erroneous calculation. We also believe that the same problem exists regarding the squat jumps since the same approach was applied. However, the effect should be less prominent since it is not likely that the subjects were able to perform substantial jumps particularly with higher loads (Cuk et al., 2014), while the breaking phase could also be less accentuated.

The discussed problems are still frequent in the literature (see for review (Jaric & Markovic, 2013; Lake et al., 2012)) and typically associated with the incorrect processing of the data obtained from linear position transducers attached to the moved load, such as to the barbells lifted in various exercises. Some researchers have been deceived by such an approach where they missed taking into account the mass of the body segments moved together with the applied load. They have also frequently neglected that the centre of mass of the system (i.e., load plus the involved body segments) typically moves at lower velocities than the load by itself. The applied linear position transducers could have also deceived researchers when calculating the duration of muscle action in ballistic exercises since the "simplest" (but erroneous) approach is to directly assess it from the intervals of positive velocity despite a possible presence of flight phases.

To conclude, we recognize the linear position transducers as a relatively simple, cheap, and effective device that can be used for testing power and force output in lifting exercises under the condition that both proper corrections for the participating body segments and an accurate calculation of the propulsive phase duration are applied (e.g., Cormie et al., 2007b; Sreckovic et al., 2015). However, we also believe that the generally recommended method should still be the use of force platforms where double integration of the recorded force signal is expected to provide the movement kinematic and kinetic variables without a need for additional corrections (Cormie, Deane, & McBride, 2007; Cuk et al., 2014; Markovic et al., 2011; Nuzzo et al., 2010). Even more accurate results could be obtained by simultaneous use of force platforms and linear position transducers (Cormie et al., 2007b).

Disclosure statement

No potential conflict of interest was reported by the authors.

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