Two-Point Method: A Quick and Fatigue-Free Procedure for Assessment of Muscle Mechanical Capacities and the 1 Repetition Maximum

Amador Garcia-Ramos, PhD¹,² and Slobodan Jaric, PhD³,⁴,⁵

¹Department of Physical Education and Sport, Faculty of Sport Sciences, University of Granada, Granada, Spain; ²Faculty of Education, CIEDE, Catholic University of the Most Holy Conception, Concepción, Chile; ³Biomechanics and Movement Science Graduate Program, Department of Kinesiology and Applied Physiology, University of Delaware, Newark, Delaware; ⁴Faculty of Sport and Physical Education, University of Belgrade, Beograd, Serbia; and ⁵Department of Human Motor Behavior, The Jerzy Kukuczka Academy of Physical Education in Katowice, Katowice, Poland

Supported by the Serbian Research Council under Grant 175037.

ABSTRACT

The force-velocity (F-V) and load-velocity (L-V) relationships have received the attention of the scientific community for a long time (38,55). More recently, the proliferation of affordable sport technology has allowed strength and conditioning professionals to routinely evaluate these relationships in various movement tasks (1,3). The F-V relationship provides a higher informational value than routinely applied tests typically conducted under a single mechanical condition because it allows to discern among different muscle mechanical capacities (23,37). However, the L-V relationship has been used to predict the 1 repetition maximum (1RM) (14,17,24,31). Therefore, the individual assessment of the F-V and L-V relationships is highly
recommended to be used for prescribing and implementing effective individualized resistance training programs. However, both relationships have been obtained from different mechanical conditions that made the related procedures not only long lasting but also prone to fatigue. Therefore, the objective of this article is to present the 2-point method (i.e., the method based on tests performed under only 2 loads or 2 velocities) as a quick and fatigue-free procedure able to reliably and accurately determine both F-V and L-V relationships. We will discuss the theoretical basis and the most important methodological issues related to the application of the 2-point method for obtaining reliable and valid F-V and L-V relationships.

THEORETICAL BASIS

FORCE VELOCITY RELATIONSHIP AND ITS PARAMETERS

It is generally accepted that muscles have distinctive mechanical capacities that allow them to produce maximal levels of force ($F_0$), velocity ($V_0$), and power ($P_0$) (27). The main limitation of the standard testing procedures conducted under a single mechanical condition (e.g., a vertical jump performed against a preselected load) is that their single outcomes do not allow for distinguishing among different mechanical capacities of the muscles (27). It should be noted that the force, velocity, and power outputs obtained under a single load are interdependent (i.e., higher force outputs inevitably produce a higher velocity and, consequently, higher power outputs) (13,27).

However, an important characteristic of the F-V approach is that $F_0$ and $V_0$ are independent of each other because a higher $F_0$ does not necessarily imply a higher $V_0$. A number of studies have revealed that the parameters of the typically linear F-V relationship (i.e., $F_0$, $V_0$, $a$, and $P_0$) are reliable and at least moderately valid (9,13,15,28,53).

Briefly, to obtain the F-V relationship parameters, the force and velocity data collected from a functional movement (e.g., jumping, cycling, lifting, running, pushing, etc.) conducted under 2 or more loading or velocity conditions provide a line that determines the following F-V equation: $F(V) = F_0 - aV$, in which $F_0$ represents the force intercept (i.e., force at zero velocity) and $a$ is the slope of the F-V relationship (27,48). The maximum velocity ($V_{0\max}$) at zero force corresponds to $F_0/a$. Finally, because of the high linearity of the F-V relationship, $P_0$ can be calculated as $P_0 = F_0 \cdot V_0 / 4$. Therefore, the F-V relationship should be recommended for the routine testing of muscle function because it provides higher informational value than the standard test conducted under a single mechanical condition (27,28,48).

The F-V relationship parameters have been used to gain a deeper insight into different issues related to muscle function, rehabilitation, injury prevention, and sport performance. Specifically, it has been shown that F-V relationship parameters (i.e., $F_0$, $V_0$, $a$, and $P_0$) may distinguish between individuals of different physical fitness levels (10) and age (56), as well as between athletes of different disciplines (22). The F-V profile may also partly explain between-subjects differences in bilateral deficit during ballistic lower limb push-off (49). Finally, there may be a subject-specific optimum balance between $F_0$ and $V_0$ capacities (i.e., the F-V slope), which maximizes ballistic performance for a given value of $P_0$ (32,33,46). Therefore, the training programs should target a minimization of the F-V imbalance (37). Taken collectively, these results highlight the importance of the F-V relationship assessment not only for basic research in various fields of human movement science but also for better prescription and monitoring of resistance training programs by strength and conditioning practitioners.

LOAD VELOCITY RELATIONSHIP AND 1 REPETITION MAXIMUM

The 1RM is one of the most common measurements used by strength and conditioning professionals either for assessing the effects of training procedures or for prescribing specific relative loads (i.e., %1RM) (8,52). However, the direct determination of the 1RM typically involves a number of limitations, such as being prone to fatigue and injuries, being time-consuming and impractical for large groups of subjects, whereas 1RM value can change quickly as a consequence of training. To solve these problems, several indirect methods have been proposed to predict the 1RM. The prediction of the 1RM through the L-V relationship has attracted considerable attention over recent years (24,31,34,36). The L-V relationship, interpreted as the relationship between the %1RM and movement velocity, has been explored in a variety of resistance training exercises such as the bench press, bench pull, pull-up, squat, or leg press (7,17,24,39,50,51). The strong and approximately linear L-V relationship observed in the cited studies motivated a proposal for generalized group equations to predict the %1RM from the recorded velocity output (7,17,24,39,50,51).

The information presented above suggests that testing the movement velocity is a safe and time-saving method of predicting the 1RM. However, generalized group equations are associated with at least 4 important drawbacks that limit their use in practice. First, an independent generalized group equation would be required for each exercise because the L-V relationship is inevitably exercise-specific (7,50). Second, although the differences in the L-V relationship between different exercises may be caused by the differences in the velocity of the 1RM, recent studies have shown that the inclusion of the stretch-shortening cycle significantly increases the velocity associated to each %1RM compared with the concentric-only execution (17,40,42). Third, a systematic bias in the velocity outputs may exist between different devices.