Reliability and reproducibility of two different inertial dynamometers for determining muscular profile.

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1 Introduction

The ability to produce maximal power output appears to be crucial in many sports. In addition, the force-velocity relationship characterizes the dynamic capability of the neuromuscular system. Measuring the maximal force, velocity and power with accuracy during strength exercise should be useful in monitoring training.

Iso-inertial assessment (constant gravitational load) could be investigated with two devices particularly appropriated in classical lifting tasks such as leg press: the Myotest® accelerometer and the Musclelab® linear encoder whose data acquisition and analyse procedure are well-adapted to use routinely.

The aim of this study was to compare mechanical variables derived from force-velocity and load-power relationships obtained simultaneously with an accelerometer and a linear encoder during incremental strength test on leg press.

2 Methods

Subjects - The subjects were 20 handball players who were accustomed to perform maximum effort during press exercises. Their mean age, height, body mass and body mass index were 25.8 ± 4 years, 188.3 ± 6.4 cm, 87.1 ± 10.9 kg and 24.4 ± 1.6 kg.m^{-2}, respectively. All gave their informed consent to take part in the study. The testing session was part of the standard evaluation procedure developed by the French Handball Federation.

Test procedures - Subjects performed one repetition concentric maximum (1RM) and concentric muscle power tests on Technogym® horizontal leg press. Prior both tests (separated for 7 days), appropriate warm-up was performed. The reference position was determined for all test conditions. Subjects performed each trial from starting knee angle of 90° to full extension. Each subject chose his preferential vertical feet position which was measured. The starting request position was obtained by adjusting the distance between seat and feet platform and replacing feet in the previously measured vertical position with soles of feet leaning against the platform.

To determine the 1RM, six to seven separate single attempts (increasing load) were performed until the subject was unable to extend the legs to the full extension. The last acceptable extension with the highest possible load was determined as 1RM. The rest period between attempts was 3 min.

The load-power relationships during concentric leg extension (with both legs) was testing using relative loads of 30, 45, 60, 70, 80 and 90% of 1RM. Subjects were instructed to thrust as fast as possible, starting from the flexed position to reach the full extension with jump when possible. Two test actions were recorded for the same load and the best reading defined as the highest velocity [3] was taken for further analyses. The time for rest between each trial was 1min and 3 min of passive recovery was given between each increased charge.

Sensors - Load displacement was analysed simultaneously with the 2 different inertial dynamometers fixed to the column of charge which allows only vertical displacement. Myotest® [4] (Myotest A.S., Sion, Suisse) measured vertical acceleration at 200Hz. Musclelab® [1] (Ergotest Technology A.S. Langesund Norway) recorded linear displacement, from linear encoder with sampling frequency of 100Hz. The Musclelab® sensor was interfaced to an electronic device. When the loads were moved by the subjects a signal was transmitted by the sensor every 3 mm of displacement. Calibration procedure of the linear encoder was performed before each session of test. No calibration procedure was specified by the manufacturer for the accelerometer.

It was possible to calculate velocity, force and power for each repetition from the 2 inertial dynamometers. The highest values of velocity, force and power reached during the concentric phase for each repetition was considered as peak values. The individual load-peak power relationship was fitted with a 2nd order polynomial regression to calculate maximal power (P_{max}, W) and optimal load ($Load_{opt}$, %RM). The maximal theoretical velocity (V'_0, m.s^{-1}) and the maximal theoretical load ($Load_0$, kg) were extrapolated from the load-peak velocity. The theoretical force (F_0, N) and velocity (V_0, m.s^{-1}) were extrapolated from the linear regression between peak force and peak velocity.

Statistics - Relationships between myotest and musclelab values for peak force, peak velocity and peak power for each load (30, 45, 60, 70, 80 and 90% of 1RM) were tested from a Spearman correlation analysis. A Wilcoxon test was used to identify differences between musclelab and myotest for P_{max}, Load $_{opt}$, V'_0, Load $_0$, F_0 and V_0.

3 Results and Discussion

A significant relationship ($p<0.0001$) was observed between values determined with musclelab and myotest for peak velocity, peak force and peak power for each load analyzed (30, 45, 60, 70, 80 and 90% of 1RM). The difference between peak values of power determined from myotest and musclelab are presented in figure 1.

The most important finding of this study was the difference between variables determined from myotest and musclelab dynamometer for maximal power (P_{max}) and maximal theoretical velocity (V_0 and V'_0) (Table1). Izquierdo and al. (2002) [3] have shown that load-velocity and load-power relationships in dynamic condition were related with sport-specific activities. It was hypothesized that both sport-specific time for force application during handball training and specific load and velocity required during strength training should influence load-velocity and load-power relationships in elite handball players. Therefore, it would be of grate interest to determine thus relationships in monitoring training induced adaptations. Our results showed that data were influenced by dynamometer. Consequently, individual muscular profile must be determined with the same inertial dynamometer.

The similar values of optimal load (Load $_{opt}$) obtained in this study with both dynamometers are closed to the value (60% 1RM) reported with handball players [3] in half squat exercise. It was recently suggested [5] that optimal load which defined the specific load (expressed in % of 1RM) to be overcome to reach maximal power output should be the reference allowing a more accurate training loads definition.

	Musclelab	Myotest
P_{max} (W)	2174.2 (322.5)	2467.4 (340.6) *
Load $_{opt}$ (%RM)	57.9 (5.2)	57.8 (8.8)
V'_0 ($m.s^{-1}$)	2.29 (0.15)	2.12 (0.17) *
Load $_0$ (kg)	384.5 (28)	406.4 (33.7) *
F_0 (N)	4434.5 (465.7)	4505.1 (517.9)
V_0 ($m.s^{-1}$)	2.71 (0.21)	2.42 (0.22) *

Table 1. Comparison between mechanical variables derived from relationships (*$p<0.001$)

The load–peak velocity relationship should be of great interest to estimate the 1RM value which is the most usual reference to prescribe training intensities [2, 5]. But, the significant difference observed in our study between values determined from myotest and musclelab for maximal theoretical load (Load $_0$) implied caution attitude with this approach.

4 Conclusions

Individual muscular profile established with musclelab or myotest should allow for better training prescription. But our study showed that data are influenced by dynamometer. It would be of great interest to analyze the sensitivity of thus dynamometers.

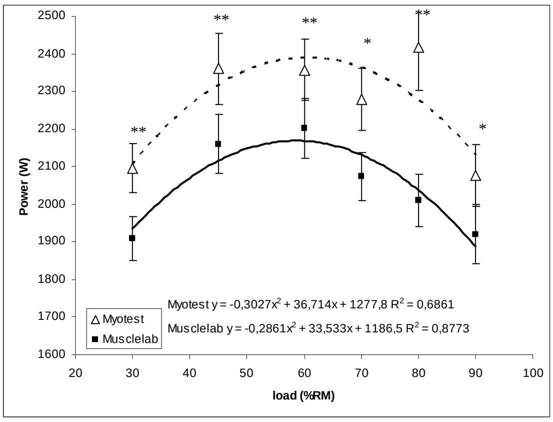

Figure 1. Load-peak power relationships (**$p<0.001$; *$p<0.01$)

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Abstract

Purpose - The aim of this study was to compare the force-velocity and the power-load relationships characterizing the extensor muscles of the lower limbs, determined from two commercial inertial dynamometers.
Methods - Twenty handball players performed a maximal concentric thrust with loads ranging from 30, 45, 60, 70, 80 and 90% of their previously determined one repetition maximum. The mechanical variables of velocity, force and power were obtained simultaneously from an accelerometer and a linear encoder. The theoretical force, speed and the maximum power were derived from both the individual force-velocity and load-power relationships.
Results – A strong relationship was observed between values determined from musclelab and myotest with peak velocity, peak force and peak power for each load analyzed (30, 45, 60, 70, 80 and 90% of 1RM) suggesting that the inertial dynamometers are reliable. Variables of theoretical velocity, maximal power derived from force-velocity and load-power relationships showed significant differences between the inertial dynamometers. In contrast optimal load was similar allowing an accurate training loads definition.
Conclusion - Individual muscular profile was influenced by dynamometer.