Reliability and validity of a novel custom-built isokinetic dynamometer

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ABSTRACT

Purpose: The purpose of this study was to validate and assess the reliability of a custom-built isokinetic dynamometer. Methods: Twelve healthy, male participants (27 ± 4 yr, 80 ± 4 kg, 179 ± 2.2 cm) performed concentric knee extensions on 3) a dynamometer constructed using a leg extension machine with a computer controlled cable resistance machine (Quantum) and 2) a commercially available dynamometer (Cybex, Human Norm) to determine reproducibility of the Quantum. Validity and reliability was assessed by comparing 15 maximal effort consecutive knee contractions through 90° flexion on each leg using the Quantum at a linear velocity of 0.5 m·s−1 and the Cybex at an angular velocity of 180°·s−1, performed fatigue on the Quantum and once on the Cybex. Peak power (W), mean power (W), and fatigue rate (%) ([avg first 5 contractions – avg last 5 contractions]/avg first 5 contractions) × 100 were quantified. Student’s paired t-tests, coefficient of variation (CV) and intra-class correlation coefficient (ICC) were used to examine reproducibility within and between devices. Results: Significant, yet consistent, differences were demonstrated for peak power between dynamometers (Quantum: 706 ± 176 W, Cybex: 439 ± 101W, p<0.0001); however, the ICC (0.72) indicated a reasonably strong association. Repeated tests on the Quantum revealed very high reliability (ICC>0.93), with no observed difference in peak power between tests (p>0.85). The CVs for mean power were 9.4% and 13.4% for the Quantum and Cybex, respectively. Fatigue rates were similar between repeated tests on the Quantum (test1: 14.5 ± 4.5%, test2: 13.8 ± 4.3%, p>0.53) but differed between devices (Quantum: 14.1 ± 4.3%, Cybex: 5.2 ± 5.9%, p<0.003). Conclusion: Although absolute power outputs differed between devices, the off-set was consistent within subjects across devices and likely related to movement pattern and lever arm differences. As such, the Quantum independently represents a valuable tool for executing and reporting maximal knee contraction power.

METHODS

• Twelve male participants
• Randomized, crossover
• 2 visits on the 1080 Quantum (reliability)
• 1 visit on the Cybex (validity)
• 1080 Quantum
  o 15 maximal concentric knee contractions per leg at 0.5 m·s−1
  o 2 s return
  o 10 minutes rest between legs
  o 2-7 days between visits
• Humanc Norm
  o 15 maximal concentric knee contractions per leg at 180°·s−1
  o 45°·s−1 return
  o 10 minute rest between legs

RESULTS & DISCUSSION

| Table 1 | Quantum Test 1 (QT1) vs. Quantum Test 2 (QT2) | ICC | CV | SEM (W) |
| QT1 (mean and SD) | QT2 (mean and SD) | p<0.0001 | 0.835 | 0.857 |
| Muscle fatigue rate | 5.8 ± 6.0 | 2.7 ± 2.7 | 0.0001 | 4.5 |
| Peak power (W) | 706.1 ± 176.6 | 710.0 ± 172.9 | 0.857 | 6.6 |
| Mean power (W) | 396.1 ± 89.7 | 47.9 ± 5.2 | 0.893 | 10.7 |

CONCLUSIONS

Potential Mechanisms and Future Directions

Our novel combination of a 1080 Quantum dynamometer with a selectorized leg extension machine was intended to match the kicking motion and measurement achieved through traditional use of an expensive human dynamometer, such as the Cybex or the Biodex. However, the axes of rotation and associated lever arms used here differ from the Cybex or Cybex II. The unique shape of the Quantum’s cam was designed to mimic the shape of the knee joint. Our novel combination of a 1080 Quantum dynamometer with a selectorized leg extension machine was intended to match the kicking motion and measurement achieved through traditional use of an expensive human dynamometer, such as the Cybex or the Biodex. However, the axes of rotation and associated lever arms used here differ from the Cybex or Cybex II. The unique shape of the Quantum’s cam was designed to mimic the shape of the knee joint. Future planned investigations include the same protocol with a leg extension machine attached to the 1080 Quantum that possess a "snail" shaped cam, instead of the "egg-shaped" one that was presently used.

We demonstrated that there are imperfectly matched values between the Quantum and Cybex dynamometers; however, this was expected considering these two machines are constructed differently. Despite differences in the absolute power outputs, suggesting the machines should not be used interchangeably, the measures are highly repeatable with a good degree of accuracy, and findings indicate that the 1080 Quantum is sufficiently reliable on a test-re-test basis. We conclude that the novel 1080 Quantum dynamometer is the potential to be utilized in future studies employing measures of human performance with a pre/post design.