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Influence of visual feedback on knee extensor isokinetic concentric and eccentric peak torque

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Abstract

Isokinetic normative data can be invaluable in identifying an individual's strengths and weaknesses, and thus lead to a more effective use of the individual's time to minimise or overcome his weaknesses while maintaining or improving existing strength. However, visual feedback (VF) may significantly affect the result of isokinetic testing, resulting in erroneous conclusions if not accounted for. Additionally, the previous use of VF to obtain increased strength values has resulted in inconsistent findings. The purpose of this study was to examine the effect of VF on concentric and eccentric knee extensor peak torque. Twenty-two sedentary, college-aged male and female volunteers were assigned to either Group 1 ($n = 11$) or Group 2 ($n = 11$) to either perform knee extensor concentric-eccentric (con-ecc) isokinetic testing with VF or without VF (no-VF) using a crossover method. After a one-week rest, the two groups underwent knee extensor con-ecc isokinetic testing using the alternative testing condition. Each test consisted of five maximal knee extensor con-ecc isokinetic testing contractions at 60° per second on the Cybex Norm system. The data indicated significant ($p < 0.05$) differences in the concentric peak torque of Group 1, Group 2 and Combined Group following VF when compared to no-VF. The eccentric peak torque of Group 1, Group 2 and Combined Group was found not to be significantly different following VF when compared to no-VF. Further, no significant interaction effect as a result of the different groups was found. Visual feedback of torque output can improve maximum voluntary concentric contraction in isokinetic dynamometry, but not maximum voluntary eccentric contraction. It is thus recommended that VF should be consistently provided during isokinetic testing, since it can also be used to help detect and correct errors in performance as well as derive reinforcement from correct performances.

Key words: Concentric, eccentric, motivation, muscle force, visual feedback.

Introduction

Sport scientists and rehabilitation specialists have identified the need to determine the concentric and eccentric peak torque values of an athlete/patient in order to develop a safe and effective exercise programme that will meet individuals' physiological needs, facilitate the recovery process and provide basic criteria for the individual to return to his or her occupation or sport. Clinical isokinetic normative data can be invaluable, in that it provides a needs analysis of the individual's strength and weaknesses employed during their specific sporting activities (Fleck & Kraemer, 1997). By identifying these strength and weaknesses, an athlete/patient can effectively utilise his/her time to minimise or overcome their weaknesses, while maintaining or improving existing strength.

All isokinetic dynamometers have a visual display of the generated torque, either in a numerical and/or graphical form (Perrin, 1993). Contradictory evidence exists regarding the effects of the visual feedback (VF) received from the isokinetic equipment displays and the resultant peak torque (Hald & Bottjen, 1987). Perrin (1993) explained that VF as generated via the isokinetic equipment displays may improve force production in subjects, especially at lower speeds. This is possible since the eyes provide response-produced feedback (following the movement) and/or feedforward control (prior to movement) (Schmidt, 1991). The feedback mechanism increases performance, since the subject knows that performance will be required to improve on the previous performance. Feedforward may increase the performance, since the subject determines beforehand the performance required using the available 'target' information on the isokinetic dynamometry (i.e. X-axis and Y-axis graph values, etc.) (Schmidt, 1991).

The findings regarding the effect of VF on concentric peak torque during isokinetic evaluations are uncertain (Figoni & Morris, 1984; Croce, 1986; Hald & Bottjen, 1987; Baltzopoulos, Williams & Brodie*,* 1991; Dvir & David, 1996). Similarly, no definitive decision can be made regarding the effect of VF and eccentric peak torque during isokinetic evaluations (Dvir, 1995; Kellis & Baltzopoulos, 1996; Kim & Kramer, 1997). Therefore, due to the controversy regarding VF and isokinetic performance, the purpose of the study was to determine whether there was an advantageous effect when isokinetically evaluating concentric and eccentric knee extensors with the use of VF.

Methodology

Subjects

Twenty-two sedentary, college-aged males and females (mean age: 20.9 ± 7.8 years) were recruited and completed the study and their characteristics are shown in Table 1. Both males and females were included, since the effect of VF on maximal torque is not gender related (Baltzopoulos et al., 1991). Prior to participation in the study, all subjects gave written informed consent and underwent a health screening and physical examination and were allowed to discontinue the study at any time. Subjects had to be free from any known pathology that might affect their performance and, had no previous experience using computerized isokinetic dynamometry. This study was approved by the Institutional Review Board at the University of Johannesburg, South Africa (formerly Rand Afrikaans University). Subjects were assigned to either Group 1 (n = 11) or Group 2 (n = 11) to either perform knee extensor concentric-eccentric (con-ecc) isokinetic testing with VF or without VF (no-VF) using a crossover method.

Body Composition Assessment

For descriptive purposes, body mass was measured in kilogrammes to the nearest 0.1 kilogramme on a calibrated medical scale (Mettler DT Digitol, Mettler-Toledo AG, Ch-8606 GreiFensee, Switzerland) with the subjects wearing minimal clothing. Body height was measured in centimetres (cm) (to the nearest 0.1 cm) via a standard wall-mounted stadiometer.

Table 1. Subjects' baseline descriptive data

Variables	**Group 1**	**Group 2**	**Combined Group**
Age (years)	21.5 ± 7.0	20.2 ± 8.6	20.9 ± 7.8
Height (cm)	178.9 ± 12.4	175.7 ± 8.9	177.3 ± 10.7
Body mass (kg)	78.0 ± 14.1	81.7 ± 9.2	79.9 ± 11.7
Concentric Peak Torque (Nm)	229.39 ± 34.70	230.92 ± 40.40	230.16 ± 37.55

Values are means ± standard deviation.

Isokinetic Assessment

To determine if knowledge of performance in the form of VF has a differential effect on concentric compared to eccentric peak torque development in the same movement, knee extensor concentric-eccentric (con-ecc) peak torque values were measured utilising an isokinetic Cybex Norm System dynamometer (Cybex International, INC., Lumex INC., Chattannooga, U.S.A). Subjects were requested to wear comfortable and non-restrictive clothing throughout the test protocol. Lower extremity dominance was determined by kicking a ball (Kim & Kramer, 1997). It has been shown that the values obtained by either leg tend to be within 5% of each other, emphasising the need for avoidance of redundant and time-consuming replication of bilateral testing (Perrin, 1993) in healthy, sedentary individuals. The subjects either performed knee extensor con-ecc isokinetic testing with VF or without VF in a crossover method with Group 1 performing Trial 1 with VF and Trial 2 without VF, while Group 2 performed Trial 1 without VF and Trial 2 with VF to prevent between-group bias (Hald & Bottjen, 1987).

At each testing session, the subjects performed an initial warm-up consisting of light pedaling on a stationary cycle ergometer for five minutes at a heart rate of less than 100 beats per minute and five minutes of quadriceps and hamstring stretching. This was followed by positioning the subjects on the Cybex Norm System's testing bench (Dvir & David, 1996). Stabilising straps were used to secure each subject's pelvis, chest, shoulders and dominant thigh (Perrin, 1993). Each subject's right knee was aligned with the dynamometer's axis of rotation using a line passing transversely through the femoral epicondyles of the dominant knee (Magee & Currier, 1986; Perrin, 1993). The knee/hip adapter pad was then positioned three centimetre (3 cm) proximal to the medial malleolus. Subjects were then asked to put their arms across their chest for the duration of the protocol in an attempt to fully isolate the muscle acting on the knee, and to eliminate any extraneous pelvic movement that might arise as a result of a subject using his arms to generate additional force (Perrin, 1993). Each subject's anatomical zero, range of motion and gravity effect torque was established according to the parameters of Cybex International (1997). The Cybex Norm System's dynamometer was set at a damp setting of '2', to lessen torque overshoot resulting from subjects trying to 'catch up' to the speed of the dynamometer. To be able to compare the results from each subject, standardisation was required as to the range of motion each subject was allowed. Each subject was limited to 100 degrees of range of motion, with the entire range of motion lying between 5º and 105º of knee flexion.

Subjects were familiarised with the equipment and warmed-up by performing one set of five progressive familiarisation repetitions of con-ecc contractions at 60 degrees per second (60º•sec^{-1}) (Hanten & Ramberg, 1988; Stratford Bruusema, Maxwell, Black & Harding, 1990; Ford, Bailey, Babich & Worrel, 1994). The familiarisation repetitions consisted of two repetitions at 50% effort, two repetitions at 75% effort and one repetition at 100% effort (Ford et al., 1994). These familiarisation repetitions attempted to prevent excessive discomfort in the test items to follow (Mawdsley & Croft, 1982). Upon completion of the familiarisation repetitions, subjects immediately commenced with the first of the two test items.

Trials 1 and 2 consisted of five pairs of intermittent, reciprocal, con-ecc contractions with a five-second inter-contraction pause (Dvir & David, 1996). No verbal encouragement was given during all trials. In other to standaridise VF, the computer monitor was positioned one metre from each subject at chest level.

Subjects were instructed to carefully observe the monitor at all times. During the VF test, VF consisted of a computer display which provided real-time gravity-corrected muscular torque output. When performing the trials without VF, exactly the same test protocol was followed, with the exception of the use of VF. During these trials, the monitor was turned away from the subjects (Baltzopoulos et al., 1991). With both trials, peak torque values were recorded individually. After one week of rest, the two groups underwent knee extensor con-ecc isokinetic testing using the alternative testing condition in a crossover method (Hald & Bottjen, 1987).

Statistical analysis

The statistical methods that were employed included Levene's test to establish whether the groups were statistically similar (homogeneous) at baseline. The effect of VF on isokinetic peak torque was analysed using a group (e.g. Group 1, Group 2 and Combined group) by treatment (e.g. VF and no-VF) multivariate analysis of variance (ANOVA). Significant main effects or interaction effects were identified using Dunnett T3 *post-hoc* comparison. A probability value of $p \leq 0.05$ was considered as significant. Data were analysed using the Statistical Package of Social Sciences (SPSS) Version 14 (Chicago, IL).

Results

The data indicated that the three groups did not differ at the baseline regarding body mass and concentric peak torque. The data indicated significant ($p < 0.05$) differences in the concentric peak torque of Group 1, Group 2 and Combined Group following VF when compared to no-VF (Table 2). However, the eccentric peak torque of Group 1, Group 2 and Combined Group was found not to be significantly different following VF when compared to no-VF. Further, no significant interaction effect as a result of the different groups was found ($p = 0.621$).

Table 2: Peak torque changes with visual feedback and no visual feedback

Group	**Peak Torque**	**With visual feedback (VF) (Nm)**	**No visual feedback (no-VF) (Nm)**
Group 1	**Concentric**	229.39 ± 34.70	216.95 ± 32.00*
(n = 11)	**Eccentric**	269.83 ± 36.80	260.82 ± 43.40
Group 2	**Concentric**	230.92 ± 40.40	219.03 ± 30.50*
(n = 11)	**Eccentric**	289.20 ± 44.10	282.86 ± 37.70
Combined group	**Concentric**	230.16 ± 37.55	217.99 ± 31.25*
(n = 22)	**Eccentric**	279.52 ± 40.45	271.84 ± 40.55

Nm: Newton metres; VF: Visual Feedback; Values are means ± standard deviation, * indicates $p < 0.05$ for visual feedback versus no visual feedback.

Discussion

The study found that VF improved isokinetic concentric knee extensor peak torque, but not eccentric knee extensor peak torque. These findings are noteworthy, since, if a clinician evaluates an individual with VF and subsequently without VF, an erroneous assumption about the improvement of the individual's muscle strength will be made. These erroneous conclusions could have implications on the individual, since these non-functional values may show that an individual has an adequate hamstring-quadriceps ratio, when in fact the individual might have inadequate ratio. On the contrary, if an individual has an adequate hamstring-quadriceps ratio but is found not to, an attempt to correct this could predispose the individual to future hamstring/quadriceps muscle, knee ligamentous and/or hip ligamentous injuries.

The findings of the present study are substantiated by Perrin (1993) who also demonstrated that VF can improve force production at lower isokinetic speeds. Further, the studies of Figoni and Morris (1984), Croce (1986), Hald and Bottjen (1987) and Baltzopoulos et al. (1991) also found that VF can improve maximum voluntary performance during training or testing sessions. Baltzopoulos et al. (1991) and Figoni and Morris (1984) report that VF had no effect on the isokinetic evaluation at $180°\bullet sec^{-1}$ and $300°\bullet sec^{-1}$, respectively. This is contrary to the present study, since the present study used $60°\bullet sec^{-1}$. A possible explanation why VF is more effective at lower speeds (as used in the present study) could be due to the decreased speed of contraction providing more time for the central nervous system to process the visual information displayed by the dynamometer (Kim & Bottjen, 1987; Kellis & Baltzopoulos, 1996; Brown, 2000). The findings of Dvir (1995) and Kellis and Baltzopoulos (1996) are similar to that of the present, study. These studies demonstrated no significant difference in eccentric isokinetic peak torque with or without VF. Dvir (1995) and Kellis and Baltzopoulos (1996) have postulated that eccentric isokinetic contractions may not be affected by VF since the eccentric movement itself may require too large a portion of the individual's attention with inadequate concentration being given to processing the visual data provided. However, the findings of this study are in contrast to those reported by Kim and Kramer (1997) that demonstrated increased eccentric peak torque values using VF and suggested a greater sensitivity of eccentric muscle actions to VF.

In light of the possibility of increasing concentric isokinetic performance by using VF, clinicians should either unequivocally provide for or even train their individuals to use the available visual data to facilitate increased sport performance and/or rehabilitation. Visual feedback should also be encouraged, since it can be used to help detect and correct errors in performance, as well as derive reinforcement from correct performances (Hobbel & Rose, 1993; Kim & Kramer, 1997). This has implications for the rehabilitation of orthopaedic and related traumas as these injuries cause a loss in proprioception, and VF displays may be included in the arsenal of rehabilitation techniques to facilitate a faster recovery.

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