The prediction of maximal static back strength with anthropometric measures in normal and low back pain subjects

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Introduction

The assessment of back muscle relative endurance (% maximal strength) requires the measurement of maximal back strength (BS) which is problematic with chronic low back pain patients (CLBP). The aim of this study was to develop a multiple regression equation using anthropometric measurements to predict BS and to estimate the effect of practice and related clinical factors on BS results and BS predictions.

Methods

Eighty-three male volunteers (42 healthy subjects and 41 CLBP patients, Table 1) aged between 20 to 60 years performed, in a static dynamometer (Larivière et al., 2001; Fig. 1), 2 maximal static trunk extension tasks. The maximal L5/S1 extension moment of these 2 trials was used as the BS measure.

The possible anthropometric correlates to maximal BS were identified based on previous literature and included global indices of body size, specific measures of the trunk segment and limbs, and derived variables related to body composition and muscularity were collected. Two fat free mass (FFM) estimates were derived according to Lean et al. (1996) (FFML) and to Durnin & Womersley (1974) (FFMD).

From the 83 subjects, 20 healthy and 20 patients were assessed on 3 sessions at least 2 days apart within 2 weeks to evaluate the variations of BS with practice. Perception of functional disability (Fairbank et al., 1980) and pain intensity (10 cm visual analogue scale (V.A.S)) were assessed at each day of testing.

Using the healthy subject sample (n = 42), stepwise multiple linear regression analysis was performed to predict BS with age and 26 anthropometric variables as independent variables. Using the regression model, the predicted BS was computed for the 20 healthy and 20 CLBP subjects involved in the 3 days of testing. The absolute error of prediction was calculated as the difference between the measured and predicted BS values. The effect of practice on BS and the absolute error of prediction was assessed with 2-way ANOVAs (2 Groups x 3 Days of testing) with repeated on the Day factor.

Table 1. Characteristics of the healthy and CLBP subjects

<table>
<thead>
<tr>
<th></th>
<th>Healthy subjects (n = 42)</th>
<th>CLBP patients (n = 41)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>33 (12)</td>
<td>39 (12)</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.76 (0.05)</td>
<td>1.78 (0.08)</td>
</tr>
<tr>
<td>Mass (kg)</td>
<td>75 (11)</td>
<td>82 (13)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.0 (3.1)</td>
<td>26.0 (3.6)</td>
</tr>
<tr>
<td>Oswestry (%)</td>
<td>na</td>
<td>18 (12)</td>
</tr>
<tr>
<td>Pain intensity (mm)</td>
<td>na</td>
<td>23 (24)</td>
</tr>
<tr>
<td>FABQw (%)</td>
<td>na</td>
<td>10 (7)</td>
</tr>
<tr>
<td>FABQp (%)</td>
<td>na</td>
<td>14 (14)</td>
</tr>
<tr>
<td>Back pain duration</td>
<td>na</td>
<td>76 (109)</td>
</tr>
</tbody>
</table>

a Perception of functional disability assessed with the Oswestry questionnaire (Fairbank et al., 1980); b Pain intensity assessed with a 10 cm visual analogue scale (V.A.S); c Fear avoidance beliefs questionnaire (FABQ; Waddel et al., 1993), part 1 related to work activities (FABQw) and part 2 related to physical activities (FABQp) measured at the first session; d duration of LBP (daily or almost daily) as roughly approximated from the CLBP patients memory; na: not applicable.
Results

The mean BS for the samples of healthy subjects (n = 42) and CLBP patients (n = 41) were 260 Nm (SD 54) and 193 Nm (SD 63) respectively.

Regression model

The Pearson correlation coefficients revealed poor to valuable relationship (range: 0.01 – 0.60) between each independent variable and BS. The final prediction model included two variables (FFML and thoracic depth or THORD) that accounted for 39% of the variance. Replacing FFML by FFMD reduced slightly the predictive power to 37%. The corresponding regression equations were:

\[
BS = 14.740 + 5.814 \times FFML - 4.959 \times THORD \quad (\text{adjusted } R^2 = 0.391, \text{ SEE } = 42.5 \text{ Nm})
\]

and

\[
BS = 69.338 + 5.114 \times FFMD - 5.692 \times THORD \quad (\text{adjusted } R^2 = 0.371, \text{ SEE } = 43.2 \text{ Nm}).
\]

Effect of practice and related clinical factors

The BS measures differed significantly between groups (healthy subjects > CLBP patients; \( P = 0.004 \)) and between days (Day 1 < Day 2 & 3; \( P = 0.000 \)) but no significant Group x Day interaction (\( P =0.361 \)) was obtained (Fig. 2A). The absolute error of prediction (Fig 2B) was influenced by the group (\( p=0.011 \)) but not by the day of testing (\( p = 0.160 \)). However the Group x Day interaction was significant (\( p = 0.034 \)). Separate analyses (one-way ANOVA) on each group revealed a Day effect (\( P = 0.021 \)) for the CLBP group only (Day 1 > Day 2 & 3). The Oswestry score decreased significantly (\( p = 0.001 \)) from Day 1 (18%, SD 14%) to Day 2 (14%, SD 13%) and to Day 3 (14%, SD 14%) while pain intensity remained stable (\( p = 0.350 \)) across days (Day 1: 19, SD 24 mm; Day 2: 25, SD 23 mm; Day 3: 21, SD 21 mm).

The relationship between key predictors and BS was lower for CLBP patients than for healthy subjects (FFML: 0.45 vs 0.60; AGE: -0.19 vs -0.34; HEIGHT: 0.23 vs 0.37). The relationship was even reversed for THORD with 0.23 and -0.11 for the CLBP patients and healthy subjects respectively. For the CLBP patients, no relationship was obtained between BS and Oswestry (\( r=-0.15; \ p = 0.35 \)), pain (\( r = -0.17; \ p = 0.30 \)), FABQw (\( r = -0.12; \ p = 0.46 \)) and FABQp (\( r = -0.04; \ p = 0.82 \)).
Discussion

Regression model

BS cannot be predicted from anthropometric measures without important errors ($R^2 = 0.39$). Mital & Ayoub (1980) obtain slightly better results ($R^2 = 0.46$) by the inclusion of gender as a predictor. The back extension prediction equation of Marras & Davis (2001) was less impressive ($R^2 = 0.21$) even with the inclusion of gender but they did not included anthropometric measures related to muscularity.

The best predictor of BS was FFM. In fact, FFM is a strong correlate ($r = 0.78$) of the cross-sectional area (CSA) of back muscle (Mannion et al., 2000). Because CSA is related to muscle strength (Mayhew et al., 1993), FFM is thus indirectly a predictor of back muscle strength. The slightly better results obtained for FFML support the use of the regression equation of Lean et al. (1995) and might be related to the consideration of intraabdominal fat in the estimation.

Effect of practice and related factors

The subjects were not trained to perform MVC before the determination of maximal BS. This might have impaired the relationship between anthropometric measures and BS because the activation of all the fibres in a given muscle is difficult and may require some training. As in the BS results of Graves et al. (1990), in the present study motor learning was mostly completed at Day 2 because no significant difference was observed in BS between Day 2 and Day 3.

The lower relationship between key anthropometric measures and BS for CLBP patients suggested the influence of some group specific factors. Factors such as as pain, reflex inhibition, fear of injury, self cognitive evaluation of performance are expected to influence the BS testing of CLBP patients (Estlander et al., 1994; Hides et al., 1994; Vlaeyen et al., 1995). In the present study, there was no relationship between BS and pain intensity, perception of functional disability and fear avoidance beliefs among CLBP patients. The stable pain intensity across the three days of testing suggested that this factor was probably not responsible for the increase of BS and the decrease of absolute error of prediction observed for the CLBP patients. There was a significant decrease in perception of functional disability from Day 1 to Day 2 and Day 3 (Day 2 = Day 3) but the small change (4%) was probably not of clinical significance. Other factors that might be involved are neuro-muscular or arthroge nous inhibition and the improvement of the error of prediction observed on successive days is probably indicative of a decreasing influence of these factors.

In conclusion, simple anthropometric measures were not able to predict maximal BS so this should not be used to determine submaximal load levels. This was especially true for CLBP patients who demonstrated changes in BS across repeated days modifying the relationship between anthropometric predictors and BS. However, this effect was mostly completed at the second day of testing thus indicating that baseline measures could be validly performed after a single session of training or familiarisation.

References

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