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Research article

Comparison between the Original- and a Standardized Version of a Physical Assessment Test for the Dorsal Chain - A Cohort-Based Cross Sectional Study

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Abstract

This cohort-based cross-sectional study compares the original (OV) and a newly developed standardized version (SV) of the Bunkie Test, a physical test used to assess the dorsal chain muscles. Twenty-three participants (13 females, 10 males; median age of 26 ± 3 years) performed the test, a reverse plank, with one foot on a stool and the contralateral leg lifted. In the SV, the position of the pelvis and the foot were predefined. The test performance time (s) and surface electromyography (sEMG) signals of the dorsal chain muscles were recorded. We performed a median power frequency (MPF) analysis, using short-time Fourier transformation, and calculated the MPF/time linear regression slope. We compared the slopes of the linear regression analysis (between legs) and the performance times (between the OV and SV) with the Wilcoxon test. Performance times did not differ between SV and OV for either the dominant ($p = 0.28$) or non-dominant leg ($p = 0.08$). Linear regression analysis revealed a negative slope for the muscles of the tested leg and contralateral erector spinae, with a significant difference between the biceps femoris of the tested (-0.91 ± 1.08) and contralateral leg (0.01 ± 1.62) in the SV ($p = 0.004$). The sEMG showed a clearer pattern in the SV than in the OV. Hence, we recommend using the SV to assess the structures of the dorsal chain of the tested leg and contralateral back.

Key words: Bunkie Test, musculoskeletal diagnostics, physical performance test, myofascial system, superficial backline, surface electromyography.

Introduction

In both sports and rehabilitation, the interest in connective tissues has increased, as they play an important role in force transmission, which has been observed within the so-called myofascial chains (Do Carmo Carvalhais et al., 2013; Krause et al., 2016; Stecco et al., 2018; Wilke et al., 2016). There is evidence that one such chain, the superficial backline (SBL), extends from the plantar fascia, over the Achilles tendon, the gastrocnemius muscle, the ischiocrural muscles, the sacrotuberous ligament, the thoracolumbar and spinal continuity to the skull attachment, thus connecting the muscles of the dorsal chain (Stecco et al., 2019; Wilke et al., 2016). The structures of the SBL are often affected in orthopedic disorders, which might also be influenced by pathological changes in the connective tissues or non-directly adjacent areas (Ajimsha et al., 2014; Freckleton et al., 2014; Langevin et al., 2011; Wilke et al., 2016; Zügel et al., 2018).

This concept of force transmission along chains might explain why prior surface electromyography (sEMG) investigations of a currently applied physical test, which is said to assess specific muscles, reported co-contraction of adjacent and non-directly adjacent muscles of the dorsal chain (Champagne et al., 2008; Demoulin et al., 2006).

Thus, in clinical diagnostics and screening in sports, the demand for an assessment method to examine the complete chain, instead of isolated muscles, has increased. Currently, methods that require special expertise or equipment, like elastography, are being applied in research and clinical settings (Arcidiacono et al., 2015; Zügel et al., 2018). Nevertheless, the assessment procedure is fundamental for effective and goal-oriented rehabilitation (Brumitt, 2015). Currently, the assessment often includes subjective palpation - despite its lacking validity (Chaudhry et al., 2008) - because cost effective, objective tests are unavailable for daily practice. Standardized performance tests are recommended to assess functional rehabilitation goals (Brumitt, 2015), but no test considers the complete dorsal chain (Champagne et al., 2008; Demoulin et al., 2006; Krause et al., 2016; Latimer et al., 1999; Van Pletzen and Venter, 2012; Villafane et al., 2016).

The Bunkie Test is said to assess entire chains in various static positions (De Witt and Venter, 2009). It purportedly tests the posterior power line (PPL), which is structurally consistent with the SBL, but does not comprise all the structures thereof. Therefore, we use "PPL" in the following when referring to the test (De Witt and Venter, 2009; Wilke et al., 2016). This physical test is widely used in practice and research and is proposed as a screening tool for sports (Brumitt, 2015; VBG, 2015). The results of the test are associated with common performance tests (Van Pletzen and Venter, 2012).Yet, there are no studies regarding the validity and reliability of the Bunkie Test (Brumitt, 2015; Freckleton et al., 2014; O'Neill et al., 2020; Ronai, 2015; Van Pletzen and Venter, 2012; VBG, 2015). Further, because the original test version (OV) of the Bunkie Test was barely standardized (De Witt and Venter, 2009), existing studies show slight differences in test conduction and evaluation, which leads to incomparable results, a lack of consensus concerning a precise test execution and a lack of normative values (Brumitt, 2015;

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Freckleton et al., 2014; Gabriel et al., 2021; O'Neill et al., 2020; Ronai, 2015; Van Pletzen and Venter, 2012; VBG, 2015).

Therefore, this study aimed to develop and investigate a physical test that considers the entire dorsal chain. We investigated whether the OV assesses the outcome of interest (muscles of the PPL), using sEMG. Further, in order to reach consensus in literature, we developed a standardized version of the Bunkie Test (SV) and compared the test outcomes and sEMG results between the two versions. We hypothesized that there would be a difference between OV and SV in the objective outcome parameters (performance and sEMG) and the subjective ratings of exhaustion and muscle exertion.

To avoid misunderstandings or misinterpretations, the authors would like to highlight beforehand that the concept of connective tissues linking musculoskeletal structures to myofascial chains only serves as a potential explanatory model for co-contractions in the dorsal chain and to highlight the importance of testing the total dorsal chain. With this study, we do not claim to test the fascial structures, but rather the muscles, which are potentially linked via connective tissues.

Methods

This cohort-based cross-sectional study was conducted in accordance with the ethical principles of the Declaration of Helsinki. We obtained approval from the university's ethics committee (735/20 S-KH). All participants provided written informed consent and the STROBE guideline was followed (ISPM, 2009).

Participants

Thirteen female and ten male participants volunteered in this study. According to the World Health Organization guidelines, the participants were considered recreationally active (Bull et al., 2020; McKay et al., 2022). Individuals with orthopaedic diseases or pain in the lower extremity, lower back, shoulders, elbows or those with other nonspecific musculoskeletal disorders, such as rheumatic disorders, within the previous twelve months were excluded. In addition, there must not have been any history of surgery in the back or legs or any neurological disorders.

The a priori sample size calculation (G*Power version 3.1., Heinrich-Heine-University Düsseldorf, Germany) was based on a prior sEMG study, where the comparison of two versions of a static muscle test showed a fair (r = 0.21 - 0.40) to moderate (r = 0.41 - 0.60) correlation coefficient. We considered a moderate effect size (0.5) with $\alpha = 0.05$ and $\beta = 0.80$. With an add-up of 10% to meet unforeseen events our sample consisted of 23 participants.

We included all 23 participants (mean ± standard deviation (sd) age, 26 ± 3 years; weight 68 ± 14 kg; height, 1.71 ± 0.10 m) in the final analysis. Twenty-two of the participants reported they were right-leg dominant, while the remaining participant was left-leg dominant.

Study procedure

The testing session lasted 60 min and took place at the laboratory of the Technical University of Munich. Participants performed the OV and SV in a randomized order with a 15-min rest in-between (Champagne et al., 2008; Latimer et al., 1999). Both legs were tested, starting with the dominant leg (Cavanaugh et al., 2017; Van Melick et al., 2017). Four master students in the field of sports- or health science, who were blinded to the aim of the study, were trained to examine the tests.

Definition of the variables

The primary outcomes, measured for both legs, were "test performance", measured in seconds, and sEMG results. The secondary outcomes, "level of exhaustion" and "muscle exertion" were reported only after each test version.

Performance in the OV

The Bunkie Test was conducted as described in the original protocol (De Witt and Venter, 2009). Participants placed their forearms and hands in the pronated position on a mat with the shoulders over the elbows, the heels on a box (30 cm), and both legs straightened (Figure 1a). To assess one leg, participants lifted the pelvis to a neutral position and then raised the contralateral leg approximately 10 cm off the box. Performance, indicated by the duration of the correctly maintained test position (s), measured using a stopwatch. The test was terminated if the participants reported any feeling of burning, cramping, pain or strain, ended the test due to fatigue or reached the cut-off score of 40 s according to the original test report (De Witt and Venter, 2009). If the participants were not able to maintain a neutral position, they were verbally corrected by the examiner and allowed to correct the position once. If there were any further deviations, the test was ended. After a 30-s pause, the procedure was repeated for the contralateral leg (Brumitt, 2015; De Witt and Venter, 2009; Ronai, 2015; Van Pletzen and Venter, 2012).

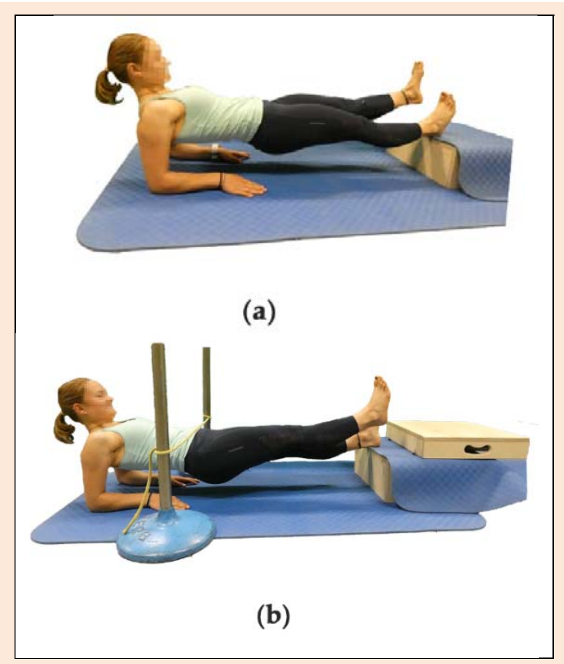

Figure 1. (a) The original- and (b) standardized version of the Bunkie Test. The test positions are shown from different angles to present both, the rotation position of the foot and the height of the second box.

Performance in the SV

To reduce the influence of individual investigator expertise on the visual detection of deviations from the neutral position, the horizontal pelvis position was marked with a rubber band stretched between two fixed stators. The participants aimed to be in contact with the rubber band throughout the test. In addition, the height of the lifted, contralateral foot was marked with a box (10 cm) (Figure 1b). The testing procedure was identical to that for the OV (De Witt and Venter, 2009).

Surface electromyography

Skin preparation and electrode placement were performed according to the SENIAM guidelines for the M. erector spinae (iliocostalis) (*es*), the M. gluteus maximus (*gm*), the M. biceps femoris (*bf*) and the M. gastrocnemius (lateralis) (*ga*) (Hermens et al., 1999). All eight muscles were measured during each trial, meaning the muscles of the right leg were investigated when the right leg was tested, but also when the left leg was tested, and vice versa. Muscle activity (sampling frequency = 1000 Hz) was measured via a wireless sEMG (Myon 320, Myon, Switzerland) and captured with proEMG (prophysics AG, CH). SEMG data were processed in MATLAB (R2020b, MathWorks, USA). First, start and end of each trial was evaluated via visual onset and endpoint determination (Micera et al., 2001). Second, data were filtered with a 10 - 450 Hz bandpass, fourth-order zero-lag Butterworth filter and checked for irregularities. Third, we assessed the sEMG data through power spectral analysis. Therefore, we calculated the median power frequency (MPF) over time (Kuthe et al., 2018; Yousif et al., 2019), using short-time Fourier transformation (Coorevits et al., 2008) with a 500 ms gliding Hanning window for each participant between the individual start- and end points. To indicate potential fatigue due to the isometric holding activity (Champagne et al., 2008), we performed a linear regression analysis on the MPF values to calculate the rate of decline of the MPF slope over time (MPF/time) (Figure 2) (Champagne et al., 2008).

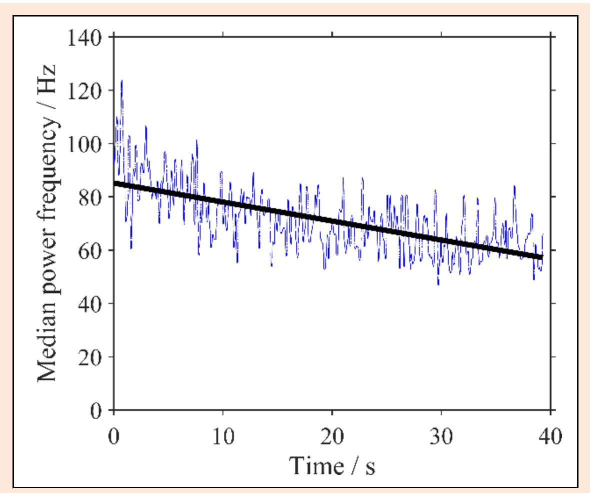

Figure 2. Sample data (M.biceps femoris of the tested leg in the standardized test version) of the power spectral analysis using the surface electromyography signal. Blue line = median power frequency (MPF), calculated using short-time Fourier transformation (500ms gliding Hanning window). Black line = Linear regression MPF/time slope.

Subjective exhaustion and muscle exertion

Participants verbally rated the level of exhaustion on a Borg scale (Borg CR-10 scale) for the OV and SV after each test (for both legs). The Borg CR-10 scale is scored between 0 (no exertion) and 10 (maximal exertion) (Williams, 2017). After each test, participants were asked to name "one or more body areas where they subjectively felt the most muscle exertion during the Bunkie Test". The answers were then summarized into the main categories: hamstrings, calves, abdomen, shoulders, gluteal muscles, plantar foot and knee- or forearm muscles.

Statistical Analysis

Statistical analysis was performed using R (version 3.5.1, R Core Team, AUT) (R Core Team, 2018). We tested for normal distribution with the Shapiro-Wilk test. For parametric data (participants' data, sEMG and subjective exhaustion), the mean and sd were calculated. Test performance values were not normally distributed and are therefore presented as median and interquartile range (IQR). The ratings of the muscle exertion were summarized into categories and are shown in total numbers per category. The exhaustion ratings (Borg CR-10 scale) for the OV and SV were compared with the paired samples t-test as data was normally distributed. For non-parametric data (performance times), the Wilcoxon test was applied to compare the results of each tested leg (dominant and non-dominant) between both test versions.

The mean (sd) MPF/time regression slope of the sEMG results for each muscle of the right and left leg/side –when tested and not tested– are presented for the OV and SV. For a more clear and comprehensible presentation of these results, the mean (sd) of the MPF/time regression slope values of the right- (when tested) and left side (when tested) were summarized into the category "tested side" and vice versa. Further, to evaluate if the tested and non-tested sides were differently strained, the results were compared with the Wilcoxon test and the effect size (r) was calculated, since data were not normally distributed. An effect size (r) of $0.10 \leq 0.3$ was considered small, $0.30 \leq 0.5$ was moderate and ≥ 0.5 was large (Cohen, 2013). A p-value of $\leq .05$ was considered significant.

Results

Test performance

The performance results of the two versions did not differ for either the dominant (median ± IQR OV: 40 ± 0 s; SV: 40 ± 7.5 s, p = 0.28) or non-dominant leg (OV: 40 ± 3.5 s; SV: 40 ± 15.5 s, p = 0.08).

Surface Electromyography (sEMG)

The excluded sEMG data are listed in Appendix A. For the SV, three of the four muscles (excluding *es*) for the tested leg showed a negative MPF/time slope, whereas for OV all 4 muscles showed a negative slope (Figure 3). On the not tested side, 3 of 4 muscles showed a negative MPF/time slope for both the SV (*es, gm,* and *ga*) and OV (*gm, bf,* and *ga*) (Figure 4).

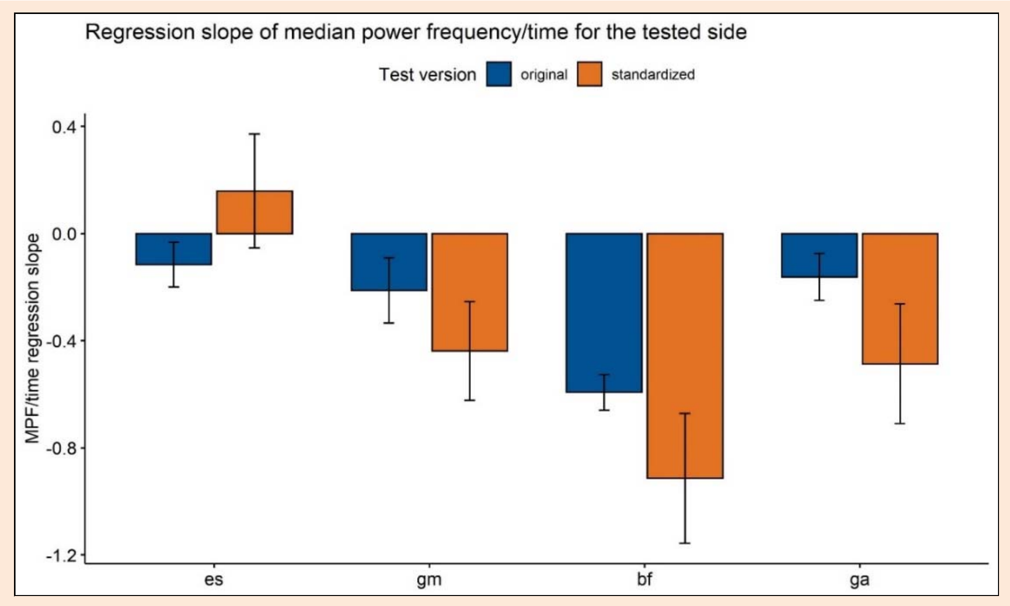

Figure 3. Mean of the median power frequency/time regression slope of the tested side during the original- and the standardized version of the Bunkie Test. MPF, median power frequency; es, M.erector spinae; gm, M.gluteus maximus; bf, M.biceps femoris; ga, M.gastrocnemius.

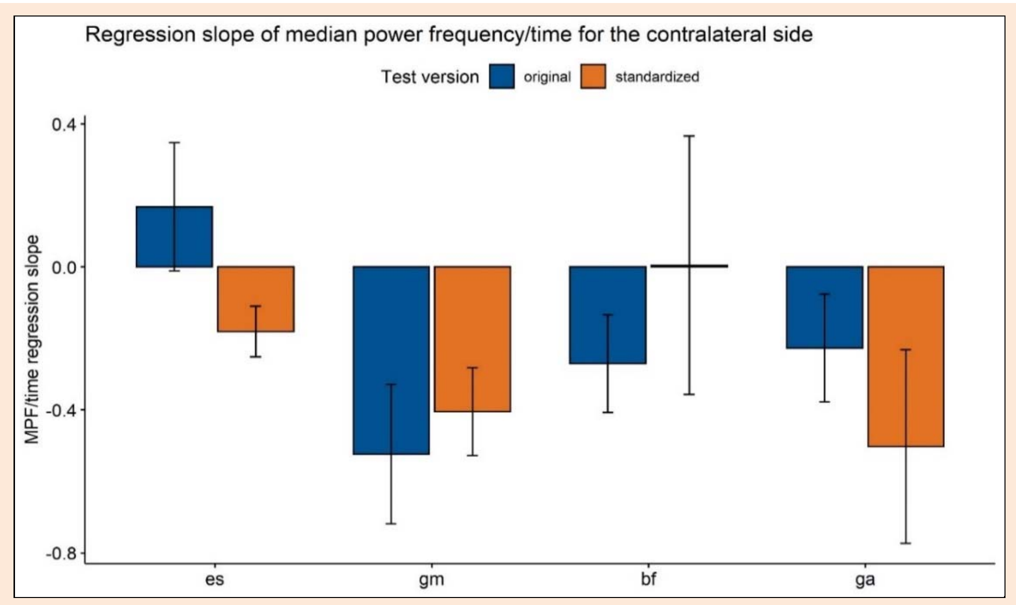

Figure 4. Mean of the median power frequency/time regression of the contralateral, not tested side during the original- and the standardized version of the Bunkie Test. MPF, median power frequency; es, M.erector spinae; gm, M.gluteus maximus; bf, M.biceps femoris; ga, M.gastrocnemius.

Table 1. Activity of the muscles of the tested and the not tested leg/side in the standardized and the original version of the Bunkie Test.

leg/side	muscle	mean MPF/time (sd) standardized test	mean MPF/time (sd) original test
not tested	es	-0.18 (0.32)	0.17 (0.82)
tested	es	0.16 (0.95)	-0.12 (0.38)
not tested	gm	-0.40 (0.55)	-0.52 (0.90)
tested	gm	-0.44 (0.82)	-0.21 (0.56)
not tested	bf	0.01 (1.62)	-0.27 (0.63)
tested	bf	-0.91 (1.08)	-0.59 (0.30)
not tested	ga	-0.50 (1.21)	-0.23 (0.69)
tested	ga	-0.49 (1.00)	-0.16 (0.40)

MPF, median power frequency; sd, standard deviation; es, M.erector spinae; gm, M.gluteus maximus; bf, M.biceps femoris; ga, M.gastrocnemius. Muscle activity is shown as median power frequency (MPF) over time regression slope.

The summarized MPF/time slope values (for right and left side tested = tested side and vice versa) are shown in Table 1. As the results slightly differed, depending on whether the right or left side was tested or not tested, we provide additional detailed data in Appendix B. The MPF/time slope of the *bf* was significantly lower for the tested leg (mean ± sd, -0.91 ± 1.08) compared to the not tested leg (0.01 ± 1.62) in SV (W(20) = 305; p = 0.004), but not in the OV (tested: -0.59 ± 0.30; not tested: -0.27 ± 0.63) (W(21) = 290; p = 0.08). The values of the other muscles did not differ between sides or test versions (Table 2).

Subjective exhaustion and muscle exertion

Participants rated their subjective exhaustion (Borg CR-10 scale) significantly lower in the OV (mean ± sd, 6.27 ±

1.56) than in the SV (7.11 ± 1.76) (t(22) = -3.233; p = 0.004; 95% confidence interval [CI]: -1.427, -0.312). After the OV, participants most frequently reported the hamstrings as the body area where they "subjectively felt the most muscle exertion" (n = 10), followed by the calves (n = 8), abdomen (n = 4), shoulders (n = 3), knee muscles (n = 2) and plantar foot (n = 2). For the SV, participants also felt "the most exertion" in the hamstrings (n = 12), but that was followed by the shoulders (n = 7), calves (n = 6), and abdomen (n = 3), with one participant citing the knee area, plantar foot and gluteal muscles, respectively (all n = 1). In addition, two participants reported feeling exertion in the forearm for the SV.

Table 2. P-value and effect size for the sEMG comparison between the tested and the not tested side for the original and standardized version of the Bunkie Test.

muscle	original test version	standardized test version
M. erector spinae	0.96 (r = 0.23)	0.21 (r = 0.43)
M. gluteus maximus	0.08 (r = 0.27)	0.12 (r = 0.25)
M. biceps femoris	0.08 (r = 0.43)	0.004* (r = 0.54)
M. gastrocnemius	0.92 (r = 0.01)	0.99 (r = 0.08)

sEMG, surface electromyography. The effect size r is classified as 0.10 ≤ 0.30 = small, 0.30 ≤ 0.50 = moderate, ≥ 0.50 large; * indicates a statistically significant difference p < 0.05.

Discussion

The performance results of the SV and OV did not significantly differ, although participants rated the SV as more exhausting. The sEMG results for most of the muscles of the PPL in the SV and OV show isometric muscle contraction-induced muscle fatigue, which was indicated by the negative MPF/time regression slope. Exceptions were the *bf* of the not tested side in the SV, the *es* of the tested side in the SV, and the *es* of the contralateral side in the OV. Further, in the SV, there was a significantly greater decline in the MPF/time slope in the *bf* on the tested side than on the contralateral side. However, MPF/time slopes did not differ between the sides for any of the muscles in the OV.

Test performance

Although participants rated the SV as more exhausting, the performance results were not statistically significantly different between the test versions. We hypothesize that this non-significant result might have been influenced by the fact that many participants reached the maximal test performance of 40 s (n, dominant: OV = 18, SV = 13; non-dominant: OV = 16, SV = 15), which seems to be unusually high performance values compared to the first reporting of the test (De Witt and Venter, 2009). Although our results are in line with prior studies (Brumitt, 2015; Freckleton et al., 2014; Gabriel et al., 2021; Ronai, 2015; Van Pletzen and Venter, 2012), this current agreement on the normative values may be questioned. A prior study reported a mean norm performance of 40 s (Brumitt, 2015), but the test was not terminated after 40 s, as proposed for the OV (De Witt and Venter, 2009). In addition, the bench height in prior studies seems to differ from that in the OV (Brumitt, 2015; De Witt and Venter, 2009; Ronai, 2015). As the aim of the test is an assessment of the integrity of the myofascial system rather than endurance performance alone, it is important that the test is immediately terminated if there are small deviations of the body position (De Witt and Venter, 2009).

Objective muscle activity and subjective muscle exertion

We observed a decrease in all tested lower extremities' muscles in both test conditions. This shift in the power spectrum toward lower frequencies has been used to indicate fatiguing isometric contraction (Champagne et al., 2008; Schoenfeld et al., 2014), resulting from metabolic changes due to restricted blood flow, a decrease in intracellular pH, or neuromuscular fatigue, either central or in the muscle (Cifrek et al., 2009). The sEMG results, in which the *bf* of the tested side in the SV was the only muscle to show significant differences from those of the not tested side, are supported by the results of subjective muscle exertion, where the *bf* was most often reported as the muscle participants felt the most exertion in the SV.

The role of test standardization

In the SV, the muscle frequency profile was most consistent for the *bf* of the tested leg. For the *gm*, the MPF/time slope decreases were lower compared to those of the *bf* of the tested side and similar between legs (tested and not tested). For the *es*, there was a higher decrease in the contralateral side.

Interestingly, there were no clear differences in the *bf* between legs in the OV, the results for the *gm* were higher in the not tested leg, and there was no fatiguing activation of the contralateral *es*.

These differences between the test versions could be explained by the more precise standardization of the pelvis- and foot position in the SV. We assume that as the position of the shoulder and the lifted leg are fixed, gravity moves the hip down, indicated by an increased hip flexion or pelvis rotation. As we tried to prevent compensation patterns in the SV, participants activated the contralateral *gm* and utilized higher lumbar extension to maintain a neutral position. We assume that these deviations of the pelvis might not have been detected in the OV. The sEMG results for the *ga* were rather inconsistent between the SV and OV. We did not expect to detect an extremely challenging contraction in the *ga* of the tested leg as the test does not explicitly target on testing the *ga*.

The potential role of the connective tissues in muscle co-contraction

In the SV, the decrease of the lower extremity muscles of the tested leg was associated with a decrease for the *es* of the contralateral side. Prior studies showed co-contractions of the gluteal muscles and the contralateral back muscles and reported a potential structural connection between these muscles via the thoracolumbar fascia (Champagne et al., 2008; Zügel et al., 2018).

Similarly, prior studies of the Sorensen Test also show co-activation of the gluteal and the hamstring muscles during the muscle endurance test for the *es*, which was also the case in this study. This could be explained by the fact that both muscles function as hip extensors. Nevertheless, studies showed that the co-activation observed during the Sorensen Test could be influenced by varying the ankle position, meaning that an increase in ankle dorsiflexion was associated with an increase in muscle co-contraction (Champagne et al., 2008; Demoulin et al., 2006).

These findings and the co-contraction of the gluteal and contralateral back muscles could support the assumption that the connective tissues of the dorsal chain, frequently referred to as the SBL, might play an important role in muscle activation and co-contraction along the chain (Champagne et al., 2008; Krause et al., 2016).

Strengths and limitations

This study was the first to use sEMG to analyze the dorsal chain muscles during the Bunkie Test, which allows an objective investigation of the dorsal chain muscles. We tested women and men in a reasonably high sample (Champagne et al., 2008), which makes our results generalizable for a healthy population of this age. Nevertheless, our study shows some limitations, which we would like to discuss.

First, measuring back muscle activity with sEMG could be criticized, but seems to be reasonably accurate compared to that of intramuscular EMG for isometric contractions (Besomi et al., 2019; Hofste et al., 2020).

Second, as the proposed test does not intend to explicitly test the *ga*, the activity thereof could rather be seen as an overflow of activity from the pre-stretched SBL via ankle dorsiflexion as we discussed in the previous section (Champagne et al., 2008; Demoulin et al., 2006). We hypothesize that the inconsistent results of the *ga* might have been negatively influenced by the lack of standardization of the foot position concerning flexion, extension and rotation in our study. Therefore, a precise standardization of the foot position should be performed in future studies.

Third, we allowed 30-s rest period in this study, as reported in prior studies (Brumitt, 2015; De Witt and Venter, 2009; Ronai, 2015; Van Pletzen and Venter, 2012), but according to a recently published study (O'Neill et al., 2020), a resting interval of one minute is preferred.

As the results were clearer for the *bf* of the tested side, the *gm* for both sides and the *es* for the contralateral sides in the SV, the SV seems to be superior to OV, which might result from a more precise standardization. Therefore, we suggest standardizing the foot- and pelvis position and other criteria to obtain more precise test performance results. Physical tests should require little time (max. 20-25 min for pre- and post-test), be cost effective, and have as simple a test set-up and procedure (Villafane et al., 2016). In summary, as the proposed test fulfills these criteria, we recommend the SV as a valid tool for testing the integrity of the PPL in daily practice in the fields of sports, physical therapy, and rehabilitation to address the deviancy of physical tests for the total dorsal chain and in general the myofascial system.

Conclusion

The proposed standardized assessment offers a rapid, objective and valid test for the dorsal chain structures. As the dorsal chain plays an important role in sports and in many pathologies, this assessment may also achieve clinical relevance. Future studies should address the reproducibility and validity of the test.

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Key points

- The standardized Bunkie Test assesses the dorsal chain muscles.
- It targets mainly the muscles of the tested leg and the contralateral lower back.
- In contrast, for the original test version the surface electromyography results were inconsistent.
- For consistent, standardized results, we recommend standardizing the foot and pelvis position precisely during the test.

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Appendix A

For the sEMG data each participant, tested leg, and test version (OV, SV) is represented in one file (total 92), where eight muscles (*es, bf, gm, ga*), respective for the right and the left side (total 736), are displayed. We excluded 3 out of 92 total trials (which comprises all 4 muscles' of one leg), plus the paired data of the other leg, due to missing data. Further, after visually scanning all 736 muscles' sEMG data for irregularities, we additionally excluded 6 muscles' data, plus the paired data from the respective not tested leg. See the detailed list therefore below:

Total trial/file (all eight muscles' of one leg plus paired data of the other leg):

- S02, dominant leg plus non-dominant leg, SV
- S17, non-dominant plus dominant leg, SV
- S21, non-dominant plus dominant leg, SV

Single muscles (plus paired data of the other leg):

- S01, dominant and non-dominant leg, *es* left and right, OV
- S01, dominant and non-dominant leg, *gm* right, OV
- S01, dominant and non-dominant leg, *bf* right, OV
- S01, dominant and non-dominant leg, *ga* right, OV
- S06, dominant and non-dominant, *bf* left, SV
- S12, non-dominant and dominant leg, *bf* right, SV
- S17, dominant and non-dominant, *bf* right, SV

S22, non-dominant and dominant, *bf* right, SV

Appendix B

The median power frequency over time regression values for the muscles of the dorsal chain during the standardized- and the original Bunkie Test are displayed separately for the right- and the left- tested and not tested leg.

tested leg	muscle	mean MPF/time (sd) standardized test	mean MPF/time (sd) original test
right	es right	0.00 (1.32)	-0.06 (0.51)
right	es left	-0.14 (0.29)	0.41 (1.62)
right	gm right	-0.67 (1.69)	-0.31 (0.88)
right	gm left	-0.60 (1.29)	-0.30 (1.38)
right	bf right	-0.96 (1.30)	-0.64 (0.53)
right	bf left	-0.27 (0.87)	-0.16 (0.94)
right	ga right	-0.33 (0.84)	0.01 (0.58)
right	ga left	-0.68 (1.91)	-0.19 (0.91)
left	es right	-0.22 (0.66)	-0.07 (0.16)
left	es left	0.32 (1.06)	-0.12 (0.44)
left	gm right	-0.20 (1.47)	-0.75 (1.36)
left	gm left	-0.18 (0.61)	-0.11 (0.71)
left	bf right	0.03 (1.91)	-0.38 (1.23)
left	bf left	-0.70 (0.41)	-0.54 (0.45)
left	ga right	-0.13 (1.36)	-0.26 (1.02)
left	ga left	-0.55 (1.28)	-0.33 (0.43)

MPF, median power frequency; sd, standard deviation; es, M.erector spinae; gm, M.gluteus maximus; bf, M.biceps femoris; ga, M.gastrocnemius.