DIAGNOSTIC ULTRASOUND AS A RELIABLE TOOL TO MEASURE MULTIFIDUS THICKNESS

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Abstract

Introduction

Lower back pain (LBP) is a recurrent issue in the general population, though it is generally seen 2-3 times more frequently in those who undergo transfemoral amputations, being considered worse than phantom limb or residual pain. It is suggested that LBP is more common in those who have a transfemoral amputation than those who have a transtibial amputation. Research thus far has seemed to focus on identifying links between unilateral amputation and LBP rather than bilateral.

The multifidus muscle is the most important dynamic stabilizer of the lumbar spine, accounting for two- thirds of lower lumbar segmental stability. A contributor to this pain may be multifidus muscle atrophy and an increase in intramuscular fat deposits and fibrous tissue infiltration, resulting in increased total muscle thickness with decreased multifidus activation and function, reducing dynamic stability capabilities and contributing to LBP. However, a lack of research in this population has led to an inconclusive explanation of the underlying mechanisms that may cause LBP. Typically, magnetic resonance imaging (MRI) is used as the gold standard to assess the thickness of the multifidus muscle, but it is costly and not as accessible to clinicians and patients. Ultrasound imaging (USI) can instead be used to assess multifidus thickness and it is reliable in the general population. Although extensive research has been performed in the general population, the reliability of diagnostic ultrasound imaging for multifidus thickness in populations who have undergone transfemoral amputations has not been studied. The purpose of this study was to evaluate intra-rater reliability of multifidus thickness measurements utilizing USI. Establishing reliability of USI in people with lower extremity amputations will allow us to confidently investigate any association between multifidus thickness and LBP.

Methods

Eleven participants who had undergone a unilateral transfemoral amputation at least one year prior to testing were recruited in the Las Vegas area for this intra-rater reliability study.

USI Procedure

Each participant was scheduled for two separate sessions, at least two days apart, but no more than 10. One examiner at the University of Nevada, Las Vegas, independently recorded the ultrasound images and measurements of the multifidus muscle.

Results

The reliability was excellent (ICC: .985 confidence interval was within an acceptable range of .955 to .995. The SEM ranged from .152 cm to .157 cm, and the MDC ranged from .421 cm to .435 cm.

Conclusion

This study showed that the intra-rater reliability of the measurements of the multifidus muscle thickness using diagnostic ultrasound imaging between two sessions showed excellent reliability. These results suggest that diagnostic ultrasound imaging is a reliable tool for measuring multifidus thickness in those with unilateral transfemoral

amputations. Utilizing USI as a tool to measure multifidus muscle thickness will allow for further investigation regarding the association of multifidus muscle thickness and lower back pain in this patient population.

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Introduction

Lower back pain (LBP) is a recurrent issue in the general population, though it is generally seen 2-3 times more frequently in those who undergo transfemoral amputations, being considered worse than phantom limb or residual pain [1]. It is estimated that around half of those who have undergone a lower extremity amputation and present with LBP report their pain levels as moderate to severe [2]. It is suggested that LBP is more common in those who have a transfemoral amputation than those who have a transtibial amputation [2]. Research thus far has seemed to focus on identifying links between unilateral amputation and LBP rather than bilateral. This may be because individuals with unilateral amputation report increased functional levels when compared with people who have undergone bilateral amputation. [3]. It has also been suggested that individuals who have undergone unilateral amputation and report LBP exhibit "altered trunk neuromuscular behaviors" as well as increased lumbar spine transverse plane excursion. [4].

The multifidus muscle is the most important dynamic stabilizer of the lumbar spine, accounting for two-thirds of lower lumbar segmental stability [6]. One theory suggests that a contributor to this pain is multifidus muscle atrophy and an increase in intramuscular fat deposits and fibrous tissue infiltration, resulting in increased total muscle thickness with decreased multifidus activation and function, reducing dynamic stability capabilities and contributing to LBP [5,7]. Though, a lack of research in this population has led to an inconclusive explanation of the underlying mechanisms that may cause LBP. Typically, magnetic resonance imaging (MRI) is used as the gold standard to assess the thickness of the multifidus muscle, but it is costly and not as accessible to clinicians and patients. Ultrasound imaging (USI) can instead be used to assess multifidus thickness and it is reliable in the general population [8,9]. Although extensive research has been performed in the general population, the reliability of diagnostic ultrasound imaging for multifidus thickness in populations who have undergone transfemoral amputations has not been studied. The purpose of this study was to evaluate intra-rater reliability of multifidus thickness measurements utilizing USI. Establishing reliability of USI in people with lower extremity amputations will allow us to confidently investigate any association between multifidus thickness and LBP.

Objective

To establish the reliability of diagnostic ultrasound as it pertains to measuring multifidus thickness in those who have undergone transfemoral amputations.

Methods

An adequate sample size of 21 participants was calculated using *G*power* with an effect size of 0.5, alpha level of 0.05, and power of 0.8 [10]. Effect size was chosen based on previous studies dealing with the same population. Eleven participants who had undergone a unilateral transfemoral amputation at least one year prior to testing were recruited by convenience sample in the Las Vegas area for this intra-rater reliability study. Inclusion criteria included the above, in conjunction with being at least eighteen years of age, having utilized a lower-limb prosthesis for at least 6 months, and having a functional ability at a K2 level or higher, defined as a community ambulator and has the ability or potential to ambulate and negotiate low level barriers such as curbs, stairs, or uneven surfaces [11].

Exclusion criteria included a history of low back surgery, a medical diagnosis of osteoporosis in the spine, acute illness, or have been instructed not to participate in therapy or rehabilitation. The ultrasound unit utilized for this study was the GE NextGen LOGIQ e scanner (GE Healthcare, Milwaukee, WI) and ultrasound images were captured of the multifidus muscle at the level of the 4th and 5th lumbar interspinous spaces.

Data Collection

This study was approved by the Institutional Review Board for Human Subjects Research at the University of Nevada, Las Vegas. Eligible participants completed informed consent forms and a brief demographics survey prior to participating.

USI Procedure

Each participant was scheduled for two separate sessions, at least two days apart, but no more than 10. One examiner at the University of Nevada, Las Vegas, independently recorded the ultrasound images and measurements of the multifidus muscle. Diagnostic ultrasound imaging was completed at each session to test for intra-rater reliability. The methods followed are similar to those used and described by Sions, et al. [12]. The subject was positioned in prone and an inclinometer was used to ensure participants were between 0-5 degrees of extension at the L4/L5 interspinous space. Pillows were used to reposition the subject to this range as needed. A 3.5-7 curvilinear MHz ultrasound transducer head was positioned longitudinally and angled medially. The position and location of the transducer was determined using palpation to ensure that the transducer head was at the level of the L4/L5 interspinous space, with the iliac crests as a reference point. Gain was adjusted before each image was captured for clarity to clearly identify the facial line and the facet joint. Depth was adjusted to allow for ideal visualization of all structures. The depth value was recorded and set up for the second visit to maintain consistency between images. Images were taken parasagittally of both the left and right multifidus muscle with the participant relaxed and prone. Imaging was randomized to determine which side of the low back would be measured first during the sessions.

Analysis

Data Analysis

ImageJ was used to determine multifidus muscle thickness. Prior to measurements, the scale was set to the depth of the image, defined by "D" in the settings. Units were set to centimeters. A linear measurement was taken from the L4-L5 facet joint to the lowermost part of the multifidus fascia line. Measurements were recorded and entered into a spreadsheet by a member of the research team.

Statistical analysis

SPSS Version 27 (SPSS, Inc. Chicago, IL) was used to analyze data. Data was also analyzed for time since amputation among the participants. The Shapiro-Wilk test was used to determine normality. Using a two-way mixed effects model, the intraclass correlation coefficient (ICC 3,1) was obtained from our test-retest results with 95% confidence interval to analyze the reliability for the multifidus muscle thickness measurements. Based on ICC cutoffs by Koo et al, interpretation of reliability values are as follows: "values less than 0.5 are indicative of poor reliability, values between 0.5 and 0.75 indicate moderate reliability, values between 0.75 and 0.9 indicate good reliability, and values greater than 0.90 indicate excellent reliability" [13]. In order to ensure the validity and applicability of the results, the standard error of measurement (SEM) and minimum detectable change (MDC) were calculated according to the following formulas, respectively: $SEM = SD \times [\sqrt{(1 - ICC)}]$, $MDC95 = 1.96 \times SEM \times (\sqrt{2})$ [12].

Results

Eleven participants, recruited by convenience sample met the inclusion and exclusion criteria and agreed to participate in this study. All eleven participants returned for the second session. Descriptive statistics are listed in Table 1, including demographic characteristics and time since amputation.

The results for the intra-rater reliability of the use of diagnostic ultrasound imaging to measure multifidus thickness in unilateral transfemoral amputees for two sessions are summarized in Table 2. The reliability was excellent (ICC 3,1: .985) per the interpretation by Koo et al, and confidence interval was within an acceptable range of .955 to .995. The SEM ranged from .152 cm to .157 cm, and the MDC ranged from .421 cm to .435 cm.

Table 3 summarizes and compares statistical data between the first and second sessions. 15 measurements were analyzed from eleven participants, with four participants who were measured bilaterally.

Discussion

Our results indicated diagnostic ultrasound is a sound tool to measure muscle thickness from an intra-rater perspective. Diagnostic ultrasound is a relatively cost-effective tool and therefore can accurately and reliably assess muscle thickness. This may result in a readily available method to view musculoskeletal anatomy and assess for atrophy to create targeted interventions to address a specific individual's needs, and monitor multifidus thickness and function throughout a plan of care.

The SEMs we calculated reflect the precision of our data collection with the ultrasound transducer between Day 1 and Day 2. SEMs also allow us to determine the MDCs, which are used to determine the minimum amount of change needed for a value to be considered as a "real change" likely due to changes in multifidus thickness instead of a random error in measurement [16].

Though ultrasound reliability is not as thoroughly studied in the lower extremity amputee population, Sions et al. found excellent measurement and procedural reliability within-day and between the 2-9 day period as established in the methods for using ultrasound in adults ages 60-85 who report chronic low back pain for at least 3 months [12]. However, this study did not examine those with amputations. Similarly, a systematic review by Nijholt et al. analyzed 17 studies and found that using ultrasound to measure muscle size in adults 60 years or older is both valid and reliable, particularly for the vastus lateralis, rectus femoris, upper arm anterior, and trunk musculature (including multifidus muscles) [13]. Our findings, though studying a different population, reflect similar ICC reliability values. This was a commonality in current research regarding ultrasound reliability in measuring muscle thickness, prompting us to research reliability in the above the knee amputee population.

This reliability study was limited in several ways. Our main limitation was our small sample size. Due to the Covid-19 pandemic, our time frame for data collection was limited, preventing us from collecting from more participants. Expanding the study to a larger sample size would likely have allowed us to assess reliability of USI more accurately in the female population, as our participant pool only included two females. Future studies should be conducted to assess the reliability of this measure in similar populations, such as individuals with below-knee amputations, as well as populations who use differing methods of locomotion, such as wheelchair propulsion or prosthetics. Our study included participants who were categorized as K2 level or higher. We suggest that future studies assess participants at specific K levels, or eliminate K levels as an exclusion criterion. Although we had excellent reliability results in our study at the L4/L5 level, it would be possible for reliability to differ at other points on the body, and therefore further studies should be conducted.

Conclusion

We observed that the intra-rater reliability of the measurements of the multifidus muscle thickness using diagnostic ultrasound imaging between two sessions is excellent. These results suggest that diagnostic ultrasound imaging is a reliable tool for measuring multifidus thickness in those with unilateral transfemoral amputations. Utilizing USI as a tool to measure multifidus muscle thickness will allow for further investigation regarding the association of multifidus muscle thickness and lower back pain in this patient population.

Appendix

Table 1: Descriptive statistics of participants

	N Statistic	Minimum Statistic	Maximum Statistic	Mean Statistic	Std. Error Statistic
Age	11	20.0	68.0	46.73	4.29
Height (cm)	11	144.78	187.96	171.11	3.72
Weight (kg)	11	51.26	103.87	77.85	5.65
Time Since Amputation (months)	11	12	408	107.63	43.25

Table 2: Reliability of measurements using ICC

Intraclass Correlation Coefficient			
	Intraclass Correlation	95% Confidence Interval Lower Bound	Upper Bound
Singles Measures	.985	.955	.995

Table 3: Data analysis between Day 1 and Day 2

	Day 1	Day 2
Sample Size	15	15
Mean	3.283	3.277
Std. Error of Mean	0.317	0.321
Std. Deviation	1.23	1.24
SEM	0.152 cm	0.157 cm
MDC	0.421 cm	0.435 cm

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