December 2015

Biomechanical Evaluation of Three Post-Kneeling Tasks: Sitting, Walking, and Standing

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BIOMECHANICAL EVALUATION OF THREE POST-KNEELING TASKS: SITTING, WALKING, AND STANDING

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A Thesis Submitted in

Partial Fulfillment of the

Requirements for the Degree of

Master of Science

in Engineering

at

The University of Wisconsin-Milwaukee

December 2015

ABSTRACT
BIOMECHANICAL EVALUATION OF THREE POST-KNEELING TASKS: SITTING, WALKING, AND STANDING

by

Alexa Hernandez Principe

The University of Wisconsin – Milwaukee, 2015
Under the supervision of Professor Naira Campbell-Kyureghyan

There are several occupations that require prolonged kneeling as part of their daily practice. Employees who kneel for a prolonged period of time have been reported to have high rates of knee and low back musculoskeletal disorders (Coggon et al. 2000, Halmstrom et al. 1992, Harkness et al. 2003, Manninen et al. 2002). These disorders result in excessive worker's compensation costs. Gallagher el al. (2009) looked at the low seam mining industry and found that companies spent the most on knee related injuries with $4.2 million and $2.7 million for low back injuries.

There is a lack of knowledge available as to what workers should do after they kneel to facilitate recovery. This study is intended to fill the gap in the knowledge base regarding recovery from extended kneeling using three different post-kneeling tasks.

The main goal of this study was to compare three different post-kneeling tasks (sit, walk, and stand) and identify which of these tasks was the most effective at promoting recovery to pre-kneeling conditions.

Nineteen subjects participated in this study. Each subject performed three trials, one for each post-kneeling task, in a random order. Each trial consisted of three parts:

pre-kneeling, kneeling, and post-kneeling. Throughout the trials muscle oxygenation and muscle activity were recorded; while range of motion was collected before kneeling and after performing the post-kneeling task. For each variable survival analysis was performed to determine statistically significant differences.

The results revealed that the limiting bio-marker for time to return to pre-kneeling baseline values is muscle oxygenation. Overall the walking and sitting post-kneeling tasks resulted in shorter times to return to pre-kneeling baseline values. However walking poses additional risks depending on the environment in which the workers are performing their tasks. Therefore the task recommended to perform after kneeling will depend on the surroundings and the job the worker has to perform following the kneeling task.

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ACKNOWLEDGEMENTS

I would like to acknowledge my advisor Dr. Naira Campbell-Kyureghyan, for giving me the opportunity to work with her for three years and being able to complete my masters. With her mentorship I've had the opportunity to develop professionally and personally. I would also like to thank Dr. Wilkistar Otieno, Dr. Kristian O'Connor, and Dr. Kurt Beschorner for serving in my committee and all their assistance during the development of this project. I would like to acknowledge the Consortium for Advanced Research in Gas Industries (CARGI) for providing me with this great research project. Special thanks to Blake Johnson, Daniel Lomo-Tettey, and Patrick Dix, for the help in data collection and data processing.

1. Introduction

There are several occupations that require prolonged kneeling as part of their daily practice. Employees who kneel for a prolonged period of time have been reported to have high rates of knee and low back musculoskeletal disorders (Coggon et al. 2000, Halmstrom et al. 1992, Harkness et al. 2003, Manninen et al. 2002). These disorders result in excessive worker's compensation costs. Gallagher et al. (2009) looked at the low seam mining industry and found that companies spent the most on knee related injuries ($4.2 million) which was higher than low back injuries ($2.7 million). The average cost per injury is relatively similar to those of other body parts; therefore the high cost reported is related to the high prevalence reported for these injuries.

Research on kneeling began primarily in the area of mining, due to the work in restricted and confined spaces. These confined spaces require miners to remain in the same posture for extended periods of time. Sharrard showed the effects of kneeling on miners, which were mainly on the skin, bursae, and menisci. For miners, kneeling cannot be avoided but with appropriate action deleterious effects can be reduced and thereby limit the disability costs and loss of working time that may result from these lesions (Sharrard, 1964).

Even though research on kneeling started in the mining industries there are also other occupations that require workers to kneel for a prolonged period of time. Field observations have shown that kneeling is also performed by roofers, aircraft baggage handlers, carpenters, mechanics, and agricultural workers. Different tasks can be

performed while kneeling: digging for miners, crawling and gluing for roofers, and lifting for aircraft baggage handlers. Lifting while kneeling has been shown to reduce lifting capacity (psychophysical), and increase metabolic and biomechanical stresses (Gallagher et al., 1988). In this case peak muscle activity for the majority of the thigh muscles was adversely related to the base support provided by the kneeling posture (Gallagher et al., 2010). Thus, muscles are affected by the interaction between the postures adopted and lifting task.

Prolonged occupational kneeling is common and is viewed as a problematic, demanding, and antiproductive task (i.e. people are less able to exert forces while kneeling) (Haslegrave, 1997). Despite the fact that kneeling is not considered a dynamic task it can be physically demanding for the muscles. It has been shown that 30 minutes of daily occupational kneeling is associated with a higher prevalence of knee osteoarthritis (Kajaks, 2008). Kneeling also induces muscle fatigue in the knee flexors and extensors (Sharrard, 1964).

Previous work by our research team (Hernandez et al., 2014) has found that when a person is kneeling blood flow to the supporting muscles is suspended due to the knee flexion and the pressure applied to the lower leg. If blood flow is restricted for an extended period of time the person can start feeling numbness and pain or discomfort in the lower leg. This was measured through feedback, in which people stopped the kneeling trial as soon as they started to feel any discomfort.

During kneeling, different postures with respect to the knee and ankle can be adopted. The knees can bent at a 90° flexion (Figure 1a), one knee on the floor (Figure 1b), or full flexion (180° flexion) (Figure 1c), while the ankles can be at a neutral posture (90° flexion) (Figure 2a) or plantar flexed (180° extension) (Figure 2b). It was previously reported that muscles reach a fatigued state faster when kneeling in full knee flexion (Porter et al., 2010).

Figure 1: Different kneeling posture adopted by workers

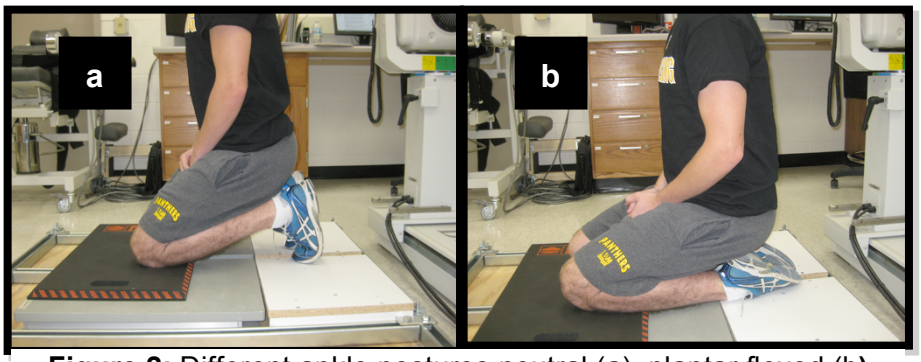

Figure 2: Different ankle postures neutral (a), plantar flexed (b**)**

The main goal of this study is to compare different post-kneeling tasks and identify which of these tasks is most effective in returning to pre-kneeling baseline values for the bio-markers being studied. Recovery will be determined by the time the bio-markers which include muscle oxygenation, muscle activity and range of motion

(ROM), take to return to their pre-kneeling baseline values. A biomechanical evaluation of the post-kneeling period is performed to investigate three different post-kneeling tasks (sit, walk, and stand), and determine which of these tasks is the most effective at returning to pre-kneeling bio-marker values after prolonged kneeling. Changes in bio-markers such as muscle activity, muscle oxygenation, and range of motion (ROM) will be quantified to assess the three different post-kneeling tasks.

Four specific aims were identified for this study:

1. Determine time required for muscle oxygenation values to return to pre-kneeling baseline values after prolonged kneeling in full flexion for the three post-kneeling tasks.
    - H01: Time for muscle oxygenation levels to return to pre-kneeling baseline conditions is task dependent.
2. Determine time required for muscle activity values to return to pre-kneeling baseline values after prolonged kneeling in full flexion for the three post-kneeling tasks.
    - H02: Time for muscle activity values to return to pre-kneeling baseline is task dependent.
3. Calculate rate of recovery for muscle oxygenation and muscle activity values for the three post-kneeling tasks.
    - H03a: Rate of recovery for muscle oxygenation is task dependent.
    - H03b: Rate of recovery for muscle activity is task dependent.
4. Verify post-kneeling leg muscle recovery through ROM of the knee.

- H04: ROM of the knee at the end of the post-kneeling task will be equal to the pre-kneeling ROM values.

The bio-markers of muscle oxygenation and muscle activity will be measured to determine time to return to pre-kneeling baseline values. Muscle fatigue will be defined as an increase in RMS amplitude, a decrease in median frequency, and a decrease in rSO_2 values; and muscle recovery will be defined as a decrease in RMS amplitude, an increase in median frequency, and an increase in rSO_2 values.

To quantify muscle oxygenation, near infrared spectroscopy (Nonin Medical Inc., MN) will be placed on the lower leg muscles, and muscle activity (Delsys, MA) will be quantified using surface electromyography sensors placed in the leg and trunk muscles. Data for muscle activity and muscle oxygenation will be separated into pre-kneeling and post-kneeling in order to quantify the time it takes for the muscles to return to their pre-kneeling baseline values. Range of motion (ROM) will be quantified through knee extension and ankle flexion and extension using a dynamometer. ROM will be measured before kneeling and after post-kneeling task has been completed.

1.1 Literature Review

There are different indicators that can be used to determine kneeling fatigue and muscle recovery. Muscle fatigue is commonly defined as an increase in root mean square (RMS) amplitude of muscle activity, shift in median frequency, and decrease in muscle oxygenation values (rSO_2) (Tachi et al., 2004); and from a psychophysical

standpoint from pain and discomfort (Iridiastadi et al., 2006). Recovery from muscle fatigue therefore can be determined by the opposite trends in fatigue, decrease in RMS amplitude, increase in median frequency (Lariviere et al., 2003) an increase in rSO_2 values (Hernandez et al., 2014), as well as a reduction in pain and discomfort. Change in range of motion (ROM) can be used in order to validate that recovery has occurred (Hernandez et al., 2014). It has been shown that after stretching the leg muscles, there is a significant increase in ROM, and holding a stretch will increase passive and active ROM (Wiktorsson-Moller et al., 1983; Harvey et al., 2006; Roberts et al., 1999; Decoster et al., 2005). Therefore, by allowing the muscles to rest and return to the pre-kneeling baseline conditions in muscle activity and muscle oxygenation, it is assumed that ROM will also return to its pre-kneeling conditions and show no change from before kneeling and after performing the post-kneeling task.

The literature reviewed identified articles in the areas of kneeling, muscle fatigue, and muscle recovery. However, there has been no research done on the biomechanics of returning to pre-kneeling values after a kneeling task, and which task(s) would lead to faster recovery.

1.1.1 Kneeling

Several research studies investigated the effects that the kneeling task has on the human body, (Sharrard, 1964; Rytter et al., 2009; McMillan et al., 2005; Coggon et al., 2000; Lau et al., 1999) as well as a comparison of different kneeling postures such as full knee flexion, 90° knee flexion, one leg support, kneeling with trunk leaning forward, and others (Mezzarane et al., 2008; Porter et al., 2010; Jensen et al., 2010;

Splittstoesser et al., 2007; Gallagher et al., 1988; Gallagher et al., 2010; Hernandez et al., 2014).

Different kneeling postures have been analyzed by several researchers. Porter et al. (2010) showed that when kneeling in full flexion there was a greater variance in pressure transmitted to the knee for the patelotendon region. Jensen et al. (2010) analyzed external knee forces at different kneeling postures among floor layers. The research team compared five different kneeling postures: kneeling on both knees at 90° flexion, one knee on the floor, full flexion, trunk parallel to the floor, and trunk parallel to the floor with a crawling task. The main finding was that postures in which the trunk is parallel to the ground generated higher external knee forces compared to other postures. Gallagher et al., (1988), looked at kneeling through different perspectives such as lifting capacity, metabolic costs, and electromyography. They found that both the perceived and actual lifting capacity is reduced while kneeling due to increase in metabolic rate and muscle activity. The study also found physiological demands such as heart rate and oxygen consumption were greater while kneeling, and consequently generating a decrease in actual lifting capacity. About a decade later Gallagher et al. (2010) examined muscle activity while kneeling in a variety of different postures (both knees on the floor, full flexion, one knee, one leg up and one leg down for support, both knees at 90° flexion and squat). Their findings showed that kneeling in full flexion resulted in lower muscle activity compared to the other postures. However, this posture has been associated with the development of meniscal tears and osteoarthritis (Coggon et al., 2000).

Sharrard, (1964) found that kneeling has adverse effects such as osteoarthritis and bursitis on the knees of miners. These effects were seen on the skin, the bursae, and the menisci. Another paper by Rytter et al. (2009), indicates that occupational kneeling increases the risk of tears in the menisci. McMillan et al. (2005) also found that work that involves kneeling is associated with a higher risk of developing knee osteoarthritis. Coggon et al. (2000) showed that there is strong evidence that knee osteoarthritis can be caused by prolonged kneeling. This is also the only paper that provides a suggestion for prevention, and indicates that workers should avoid obesity. This is due to the risk associated with developing osteoarthritis and kneeling, which appeared to interact with obesity. Other than avoiding obesity none of these papers discuss possible solutions to the adverse effects previously mentioned, or any future research to help avoid these issues.

Even though the research on kneeling investigated many different aspects of biomechanical response, kneeling time in all these studies was limited to five minutes for any of the testing protocols. Prolonged kneeling has been looked at through questionnaires and observations, but not through biomechanical testing.

1.1.2 Localized Muscle Fatigue

Localized muscle fatigue can be defined in terms of muscle activity, as an increase in RMS signal and a shift in frequency (Chaffin, 1973), and in muscle oxygenation terms as a decrease in $\%rSO_2$ values (Tachi et al., 2004). Several articles that were reviewed discuss localized muscle fatigue, but only a few of these look into fatigue induced from a static posture (Iridiastadi et al., 2007; Rose et al., 2014; Jackson

et al., 2001; Iridiastadi et al., 2006; Tachi et al., 2004; De Luca, 1984; Sjogaard et al., 1988). Iridiastadi et al. (2007) developed a model to predict fatigue across various static tasks as a function of muscle endurance. However, the models were only able to explain 25-60% of the variability in the data. This is addressed by the researchers indicating that they did not take gender into account in building the model, which could have been a factor due to differences in muscle mass and morphology. In addition, they limited the exercise period to only one hour, and they used a small sample size which may also have an effect in the variability of the models.

De Luca (1984) looked into fatigue associated with changes in physiological processes, and specifically into fatigue caused by sustained or repeated muscle contractions. He found that there is a relationship between the frequency shift on the signal, the conduction velocity of muscle fibers, the pH of the interstitial fluid and blood flow within a muscle.

Rose et al. (2014) performed a series of experiments in which subjects had to push a handle at shoulder height with a certain static pushing force while in a seated posture that resembled a construction work posture. It was found that the forces generated are lower at the end of the task, and that the muscle activity rises above the initial value. These factors both indicate that the muscle was fatigued. Jackson et al. (2001) performed a test on the lumbar spine of felines. The research team exposed the feline spines to 20 minutes of muscle fatigue (flexion), and found that those 20 minutes generated a fast decrease in muscle activity and initiation of spasms. EMG measurements demonstrated an initial hyper-excitability in flexion, followed by an exponential recovery of muscle activity.

Localized muscle fatigue was also investigated during the intermittent static tasks by Iridiastadi et al. (2006). The study investigated muscle fatigue through reduction in muscle strength, and by changes in EMG amplitude and spectral distribution. In this protocol the researchers varied contraction levels, duty cycle and cycle times. They found that endurance time and fatigue were dependent on the task parameters. Endurance times were shorter with high contractions and cycle times.

Localized muscle fatigue has not only been investigated through muscle activity. Sjogaard et al. (1988) analyzed muscle fatigue from the perspective of blood flow and lactaid buildup. She mentions that highly repetitive or monotonous jobs generate impairment in transport of substances within the muscle (i.e. blood). This research team utilized a knee extensor and handgrip protocols, which generated fatigue during prolonged contractions, and indicated that the changes in blood flow as well as a disturbance in potassium homeostasis, play a role in the development of muscle fatigue during the contractions.

Belardinelli et al. (1994) introduced a non-invasive method to monitor localized muscle fatigue via Near Infrared Spectroscopy (NIRS). Tachi et al. (2004) looked into the influence of the circulatory difference on muscle oxygenation and fatigue to the Tibialis Anterior while performing dorsi-flexion exercises. Muscle activity and muscle oxygenation were recorded. In order to address the muscle oxygenation decrease the exercise was done with and without blood restriction. The changes in muscle oxygenation levels influenced the progression of muscle fatigue while there was no blood volume restriction. When blood flow was restricted, however, the changes in muscle oxygenation were nonexistent. The research team found that muscle activity

increased as the exercise advanced. This happens because the subject is trying to maintain a constant contraction force, which will progressively reach the limit of endurance (Bigland-Ritchie et al., 1986; Moritani et al., 1987). Muscle oxygenation significantly decreased across the trial which could be explained by an increase in intramuscular pressure, which restricts the blood flow in muscles during the contraction (Sadamoto et al., 1983). Changes in muscle oxygenation influenced the progression of muscle fatigue, which was demonstrated with an increase of RMS values and a shift of median frequency.

1.1.3 Recovery from Localized Muscle Fatigue

There is very limited research in muscle recovery from localized fatigue (Lind, 1959; Jackson et al., 2001; Lariviere et al., 2003)especially when maintaining a posture for a prolonged period of time is a factor.Researchers found that after performing short fatiguing contractions, rest periods of 10 to 15 minutes allow the back muscles to return to their pre-exercise contractions. Subjects performed trunk extension fatiguing trials, and RMS and median frequencies were evaluated and analyzed to assess fatigue and recovery (Lariviere et al., 2003). However the research team did not collect data continuously, only after allowing the subjects to rest for 10 or 15 minutes. Jackson et al. (2001), in their study on feline spines, showed that following 20 minutes of passive flexion, there was an exponential recovery of muscle activity, but full recovery was not obtained until after seven hours of rest. Seven hours of recovery were needed because

the static flexion of the lumbar spine has an effect on its viscoelastic tissues, which could result in spasms, therefore requiring long rest periods.

1.1.4 Summary

Even though kneeling poses a risk to workers, little research has been done to identify ways to avoid the effects of these risks. Over 30 articles were reviewed for this study (Table 1). Although several articles are not specific to recovery after kneeling, they were chosen because they provided insight to some aspect of this study. In particular, the articles discuss muscle activity while kneeling, knee pressure, use of knee pads/mats while kneeling, adverse effects of kneeling, muscle fatigue and recovery, knee and ankle posture while kneeling, and muscle oxygenation. The literature review identified 14 articles that investigated the kneeling task with its variations. However none of them looked at the period after the kneeling task. Eight articles were found that look at muscle recovery but none of these look at the kneeling task as a predecessor. Several scientists investigated muscle fatigue. 17 articles were identified, however only a small number of these related muscle fatigue to kneeling. Of the biomarkers relevant to this study, muscle activity has been more widely investigated, with 20 articles related to muscle activity that were relevant for this research; while muscle oxygenation had only 5 articles that were valuable in this context.

From the literature review, it is clear that there is very limited research done in the area of muscle recovery after kneeling. Thus, there is a lack of knowledge available as to what workers should do after they kneel to facilitate recovery. This study is

intended to fill the gap in the knowledge base regarding recovery from extended kneeling using three different post-kneeling tasks.

Table 1: Summary of the reviewed literature

Article information			Topics											
	Author	**Date**	**Kneeling**	**Muscle recovery**	**Muscle fatigue**	**Prolonged kneeling**	**Knee posture**	**Ankle posture**	**Task (Sit, walk, stand)**	**Kneeling duration**	**Adverse effects of kneeling**	**Occupational kneeling**	**Muscle oxygenation**	**Muscle activity**	**Range of motion**
1	Lind	1959		x											
2	Sharrard	1964	x			x	x				x	x			
3	Sadamoto et al.	1983			x								x		
4	Bigland-Ritchie et al.	1986			x									x	
5	Moritani et al.	1987			x									x	
6	Gallagher et al.	1988	x		x									x	
7	Bennett et al.	1989							x					x	
8	Belardinelli et al.	1994			x								x		
9	Intiso et al.	1994		x										x	
10	Gandevia et al.	1995			x										
11	Haslegrave et al.	1997	x			x	x				x				
12	Callahan et al.	1999		x					x					x	
13	Lau et al.	1999									x	x			
14	Coggon et al.	2000	x			x					x	x			
15	Sinkjaer et al.	2000							x					x	
16	Jackson et al.	2001		x	x									x	
17	Callahan et al.	2001		x	x				x					x	
18	Feland et al.	2001													x
19	Lariviere et al.	2003		x	x									x	
20	Aruin et al.	2003							x					x	
21	Tachi et al.	2004			x								x	x	
22	McMillan et al.	2005	x							x	x				
23	Olufsen et al.	2005							x				x		
24	Iridiastadi et al.	2006			x									x	
25	Iridiastadi et al.	2007			x									x	

	Author	Date	Kneeling	Muscle recovery	Muscle fatigue	Prolonged kneeling	Knee posture	Ankle posture	Task (Sit, walk, stand)	Kneeling duration	Adverse effects of kneeling	Occupational kneeling	Muscle oxygenation	Muscle activity	Range of motion
26	Splittstoesser et al.	2007	x				x								
27	Mezzarane	2008	x				x							x	
28	Osti et al.	2009	x												
29	Rytter et al.	2009	x			x					x	x			
30	Porter et al.	2010	x				x					x			
31	Jensen et al.	2010	x				x					x			
32	Gallagher et al.	2010	x				x								
33	Reid et al.	2010	x								x	x			
34	DiDomenico et al.	2011	x	x			x								
35	Rose et al.	2014		x	x								x	x	
36	Longpre et al.	2015			x									x	
37	Hawkes et al.	2015			x									x	
38	Sonne et al.	2015			x									x	
39	Lemos et al.	2015			x									x	

2. Methods

2.1 Subjects

Nineteen subjects (10 male and 9 female) were recruited from the University of Wisconsin-Milwaukee student population. All subjects volunteered and signed a consent form approved by the University of Wisconsin-Milwaukee Institutional Review Board (Protocol #13.321-UWM). The subjects ranged in age from 20 to 31 years with an average of 23.6 (SD 3.18) years (Table 2).

The exclusion criterion for the subjects was any knee or ankle injuries, or low back pain in the six months prior to the testing. Fifteen of the subjects were right handed, one was left handed, and two subjects mentioned that they use both hands (Table 2).

Subjects were required to complete a screening questionnaire before their first kneeling trial. Four subjects reported having previous injuries, three to the ankle and one to the back. However they were fully recovered at the time of testing and the previous injury did not affect their performance during the experimental protocol.

Table 2: Summary of subject information

Gender	Subjects	Age		Dominant Side		
		Average	St. Dev.	Right	Left	Both
Female	9	23.88	3.95	8	0	1
Male	10	23.25	2.25	8	1	1

2.2 Experimental Design

The experiments for this study were conducted in a laboratory environment. The post-kneeling tasks established were sitting, walking, and standing (Figure 3). These post-kneeling tasks were chosen because they are common postures assumed by workers right after they finish a kneeling task.

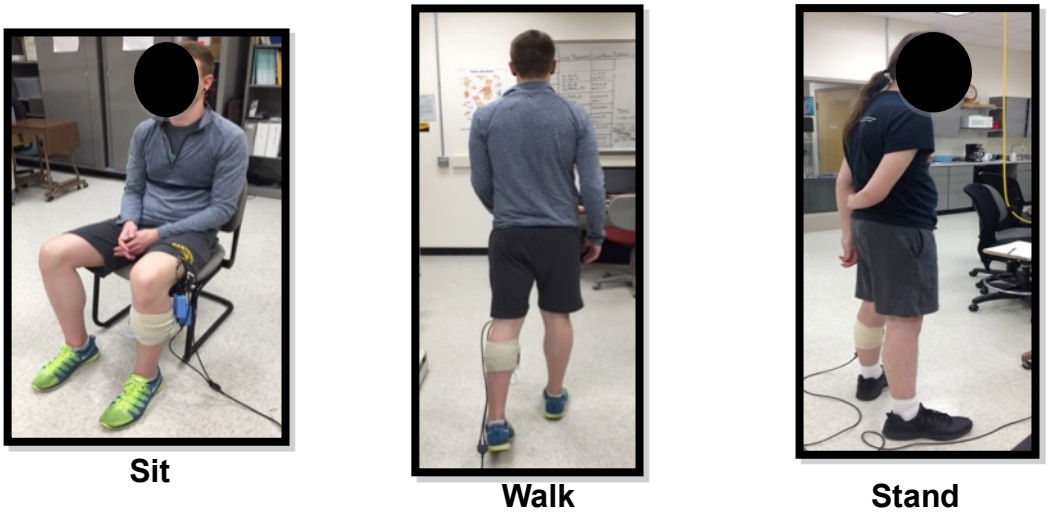

Figure 3: Subjects performing post-kneeling tasks

Each subject performed three trials, one for each post-kneeling task, in a random order, subjects were provided with rest periods between each of the trials. Each trial consisted of three parts: pre-kneeling, kneeling, and post-kneeling (Figure 4). During pre-kneeling, ROM (Biodex Medical Systems Inc., NY) was collected for the knee and ankle. The knee was positioned at a 90° flexion and subjects had to extend maximally. The ankle was flexed and extended maximally. Three minutes of baseline measurements for muscle oxygenation (rSO_2) and muscle activity (EMG) was collected. These baseline measurements were used to evaluate when the parameters returned to

pre-kneeling values. The baseline was determined prior to each kneeling trial, while the subject performed the post-kneeling task for that trial, and used for that trial only. Following baseline data collection the subject had to kneel in full flexion (180° flexion) over a kneeling mat (Figure 5) for up to 15 minutes or until he/she was no longer able to kneel due to discomfort.

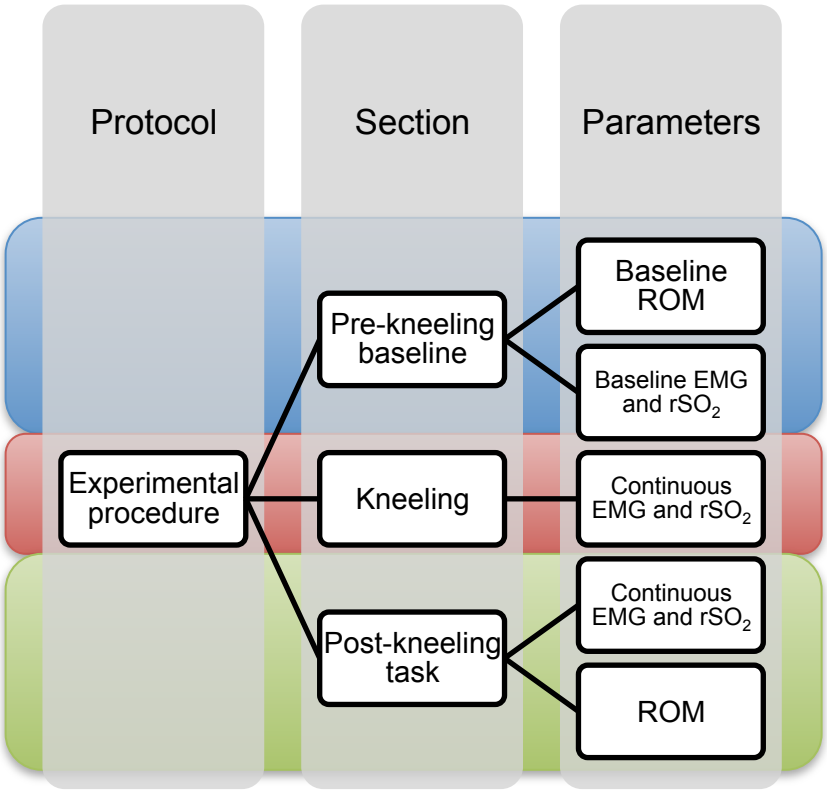

Figure 4: Graphical representation of experimental protocol

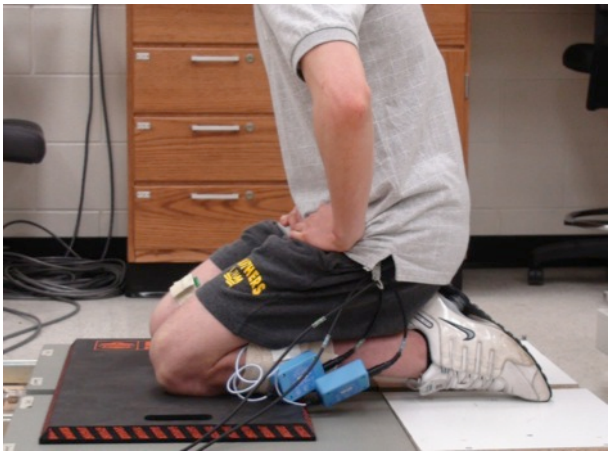

Figure 5: Full flexion kneeling posture

During the post-kneeling period, the subject was asked to follow one of the three post-kneeling tasks: sit, walk, or stand. The post-kneeling session continued until rSO_2 values returned to pre-kneeling baseline conditions. After rSO_2 values returned to pre-kneeling conditions, ROM was again collected at the knee and ankle.

2.3 Data Acquisition and Analysis

2.3.1 Muscle Activity (EMG)

Localized muscle fatigue in terms of muscle activity can be defined as an increase in RMS signal and a shift in median frequency (MDF). Double differential wireless surface electromyography sensors (sEMG) (Delsys Trigno, MA) were placed on the following muscles (Figure 6): Rectus Femoris (RF), Vastus Lateralis (VL), Vastus Medialis (VM), Medial Gastrocnemius (MG), Lateral Gastrocnemius (LG), and Tibialis Anterior (TA); while it was collected bilaterally for the Erector Spinae (ES) and Rectus Abdominous (RA). Muscle activity was collected using EMGworks 4.0 Acquisition software (Delsys Trigno, MA).

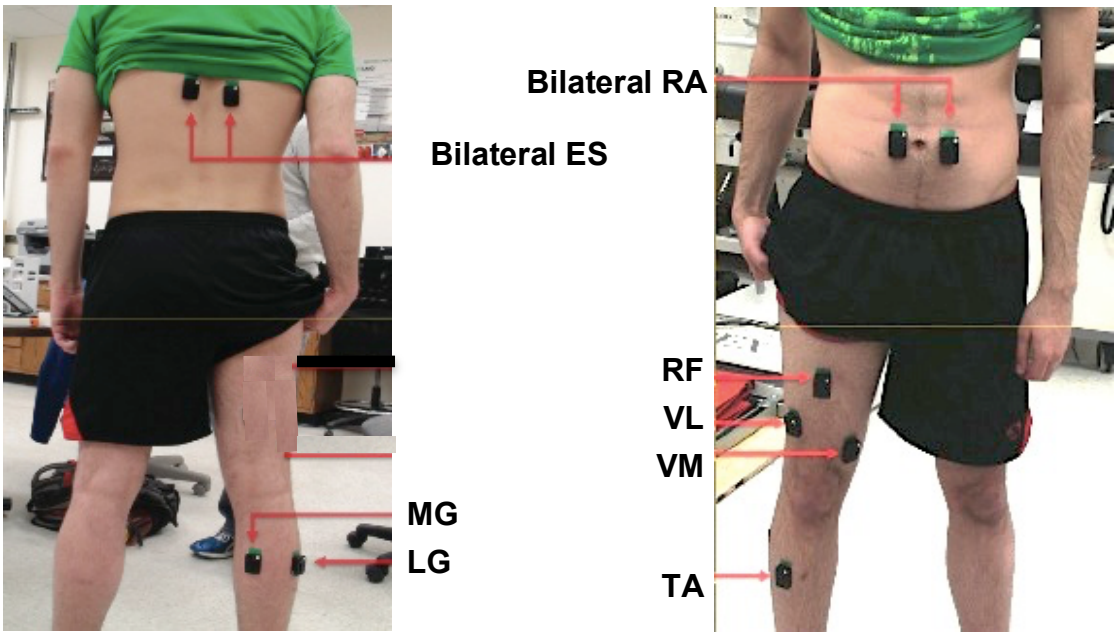

Figure 6: sEMG sensor placement

Placement areas were shaved and cleaned with rubbing alcohol to decrease any possible artifact movement or incorrect data resulting from skin-sensor interaction. After skin preparation, sensors (Figure 7) were carefully placed on each muscle belly, and they were additionally secured with athletic tape to prevent sensors from losing contact with the skin while kneeling.

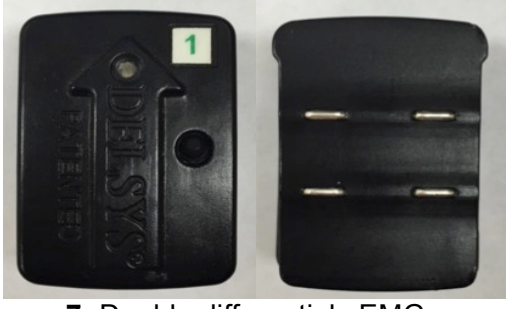

Figure 7: Double differential sEMG sensors

Muscle activity was collected at 2,000 Hz and processed using EMGworks 4.0 Analysis Software (Delsys, MA). Muscle activity was filtered with a 4th order Butterworth filter with corner frequencies of 20 to 450Hz. The corner frequencies were determined according to the hard wired system of the sensors. The smoothing technique of calculating the root mean square (RMS) was used on the filtered data. For the post-kneeling tasks of sitting and standing a sliding window of 0.250 seconds and an overlap of 0.125 seconds were used in the RMS calculation; a more robust window was used due to the static nature of the tasks. While for the walking post-kneeling task a sliding window of 0.125 seconds was used with an overlap of 0.0675 seconds.

Median frequency (MDF) was calculated using a sliding window of 0.250 seconds and an overlap of 0.125 seconds for sitting and standing, and for walking a window of 0.125 seconds and an overlap of 0.0675 seconds. Muscle activity was continuously recorded during the pre-kneeling baseline, and post-kneeling tasks.

Muscle activity was separated into two sections: pre-kneeling and post-kneeling. All the trials of RMS (Equation 1) and MDF (Equation 2) were normalized to the pre-kneeling baseline of the corresponding post-kneeling task. The pre-kneeling baseline normalization value was an average over 10 seconds of the period collected during pre-kneeling. The 10 second period was taken about the midpoint of the baseline section, where values were most stable.

$$Normalized_{RMS_i} = \frac{RMS_i}{RMS\ baseline} \quad \text{.....(1)}$$

$$Normalized_{MDF_i} = \frac{MDF_i}{MDF\ baseline} \quad \text{.....(2)}$$

Data was then grouped in 10-second intervals and averaged in order to analyze fragment by fragment during the post-kneeling task. Data was graphed and analyzed individually to identify if the muscle showed a decrease in RMS, and/or an increase in MDF; each muscle was then classified in regards to time to return to pre-kneeling baseline conditions. Return to pre-kneeling baseline values was established when values were sustained within ±10% of the pre-kneeling value.

Rate of recovery for RMS (Equation 3) and MDF (Equation 4) are defined as the difference between the value at the end of kneeling for RMS and MDF and the value of RMS or MDF at the identified recovery time, divided by the recovery time. Rate of recovery was calculated in intervals of 10 seconds until the subject fully returned to pre-kneeling baseline values

$$Rate\ of\ recovery_{RMS_i} = \frac{(nRMS_{End\ of\ kneeling} - nRMS_i)}{Time_i} \quad \text{.....(3)}$$

$$Rate\ of\ recovery_{MDF_i} = \frac{(nMDF_{End\ of\ kneeling} - nMDF_i)}{Time_i} \quad \text{.....(4)}$$

Time to return to pre-kneeling baseline values for each post-kneeling task were analyzed using survival analysis test, to determine the probability of returning to pre-kneeling baseline values across the post-kneeling period. This was followed by a Wilcoxon signed rank test and a Log-Rank test to determine if the differences between the post-kneeling tasks were statistically significant. It was the best fit for this study due to the fact that subjects reached return to their pre-kneeling baseline values at different

times, therefore generating an uneven distribution of subjects across times to return to pre-kneeling baseline values. In order to compare the three tasks in pairs p-values were obtained for each combination (sit-stand, sit-walk, and walk-stand). Using the Bonferroni method, the α value was modified to take into account the multiple comparisons, the new α value for this comparison became 0.016. Following survival analysis, a two-way ANOVA test was conducted in the recovery times of the 50% and 95% probability values, with a significance level of 95%.

2.3.2 Muscle Oxygenation (rSO_2)

Muscle oxygenation was collected using an Equanox^{TM} 2 Channel system (Nonin Medical Inc., MN). Sensors (Figure 8) were placed on the TA and the MG (Figure 9) of the subject's left leg. Muscle oxygenation levels (rSO_2) were recorded at 0.25 Hz.

Placement areas were shaved and cleaned with rubbing alcohol to decrease error. After skin preparation, sensors were placed on each muscle belly, and additionally secured with a bandage that went around the lower leg. The bandage was placed to prevent any light from filtering into the sensor and interfering with the infrared light. Muscle oxygenation levels were continuously recorded during the pre-kneeling baseline, kneeling task, and post-kneeling task. The data was imported into an Excel document for analysis.

Figure 8: Near infrared spectroscopy sensor

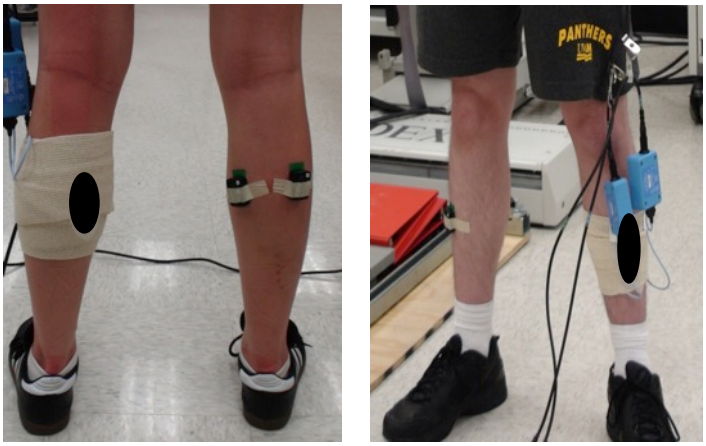

Figure 9: NIRS sensor placement

Muscle oxygenation was separated into two sections: pre-kneeling and post-kneeling. All the trials were normalized (Equation 5) to the pre-kneeling baseline. The pre-kneeling baseline value was taken from an average over 10 seconds of the pre-kneeling baseline period. The 10 second period was taken about the midpoint of the baseline section, where values were most stable.

$$Normalized_{rSO_{2i}} = \frac{rSO_{2_i}}{rSO_2\ baseline} \quad \text{.....(5)}$$

Time to return to baseline values was established as the time where rSO_2 values returned to ±5% of the initial value for at least a minute. Rate of recovery is defined as the difference between the baseline rSO_2 value and the average of the last 10 seconds of the kneeling trial, divided by the total time to return to pre-kneeling baseline values. Rate of recovery (Equation 6) will indicate how fast a person regained their muscle oxygenation.

$$Rate\ of\ recovery_{rSO_2} = \frac{(Baseline\ rSO_2 - End\ kneeling\ rSO_2)}{Time\ to\ rSO_2 recovery} \quad \text{.....(6)}$$

Time to return to pre-kneeling baseline values for each post-kneeling task were analyzed using survival analysis test., In order to determine the probability of returning to pre-kneeling baseline values across the post-kneeling period. This was followed by a Wilcoxon and a Log-Rank test in order to determine if the differences between the post-kneeling tasks were statistically significant. The Wilcoxon test checks whether the differences between the post-kneeling tasks is significant in the short term, while the Log-Rank looks at the difference on the long term. Both tests were used in the analysis to assess if the difference is in the first seconds of post-kneeling task, in the last seconds, or in both. The probability follows a non-uniform increase over time. In order to compare the three tasks in pairs, p-values were obtained for each combination (sit-stand, sit-walk, and walk-stand). Using the Bonferroni method α value was modified in

order to take into account the multiple comparisons, the new α value for this comparison became 0.016. Following survival analysis a two-way ANOVA test was conducted in the recovery times of the 50% and 95% probability values with a significance level of 95%.

2.3.3 Range of Motion (ROM)

Range of motion (ROM) was measured using a Biodex System (Biodex Medical Systems Inc., NY) dynamometer. Both knee and ankle were measured unilaterally on the subject's right leg. The full ROM for the knee was determined from 90° flexion to full extension, and for the ankle full flexion and extension were considered for a full ROM (Figure 10).

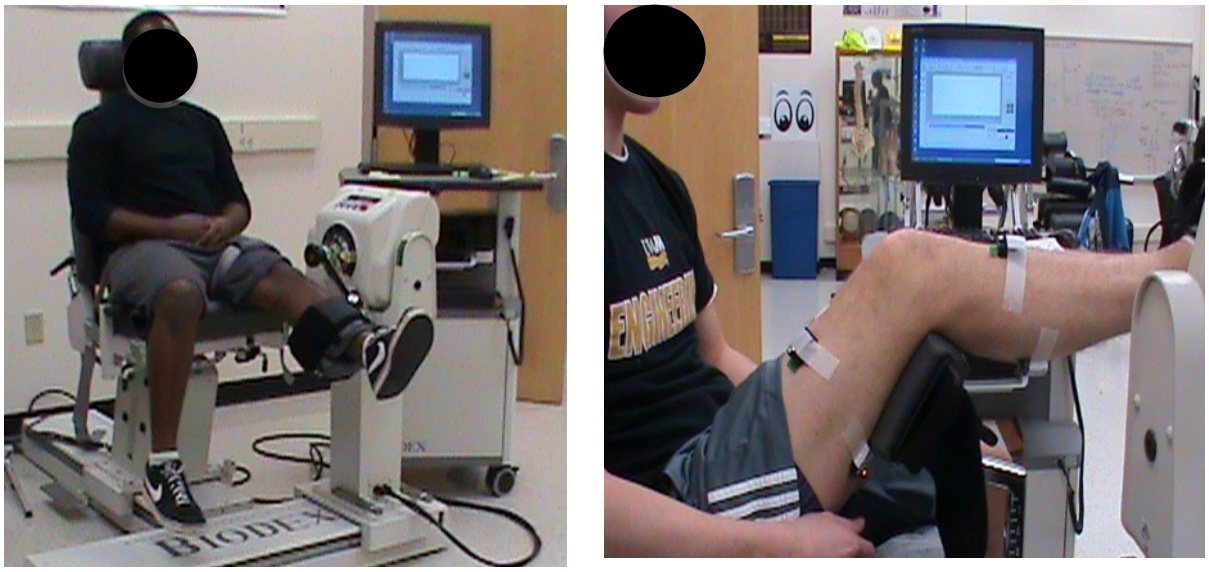

Figure 10: Knee and ankle ROM setup

ROM for the right knee was collected by fastening the leg at the thigh and ankle. The knee was then positioned at a 90° angle and the subject was asked to extend

maximally. For the ankle, the thigh and foot were strapped into the dynamometer. The ankle was then completely flexed and extended, one full flexion and extension were considered for the ROM. Three repeated trials were collected for each joint. The peak values were transferred to an Excel spreadsheet for further analysis.

The peak value from the three repeated trials before the pre-kneeling baseline was taken and compared to the peak value of the three repeated trials taken after the post-kneeling task. The percent change was then calculated (Equation 7). This variable served as validation to indicate that the subject fully returned to their pre-kneeling baseline condition.

$$Percent\ change_{ROM_i} = \frac{(Peak\ ROM_{Post-kneeling_i} - Peak\ ROM_{Pre-kneeling_i})}{Peak\ ROM_{Pre-kneeling_i}} \times 100\% \text{.....(7)}$$

A paired t-test was performed in order to determine if the difference between the pre-kneeling baseline values and the values after performing the post-kneeling task were statistically significant ($\alpha = 0.05$).

3. Results

This section is divided by bio-marker, and further subdivided by muscle. An explanation of what was observed and the statistical analysis is presented, as well as a comparison of the post-kneeling tasks for each of the muscles. A general summary of results is provided at the end of this section. For all the bio-markers results are shown in terms of the time to return to pre-kneeling baseline values, either in minutes (muscle oxygenation) or seconds (muscle activity). The statistical analysis performed for all parameters was a survival analysis due to the nature of the data where subjects returned to their pre-kneeling baseline values at different times, and the results not having a normal distribution.

3.1 Muscle Oxygenation

For both lower leg muscles, TA and MG, the return to pre-kneeling baseline rSO_2 values followed the same trend for all post-kneeling tasks. As soon as subject stood up, the influx of blood flow caused some temporary overshoot of rSO_2 beyond the baseline values. As time passed the rSO_2 values were slowly stabilized and returned to the pre-kneeling baseline level (Figures 11 and 12).

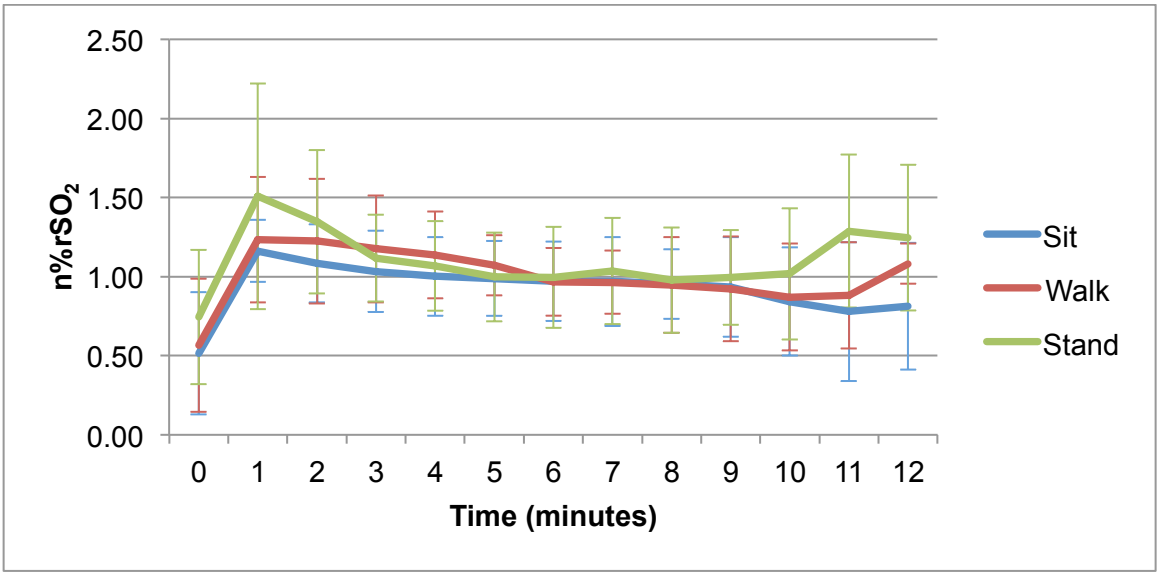

Figure 11: Normalized %rSO2 values over time for TA muscle

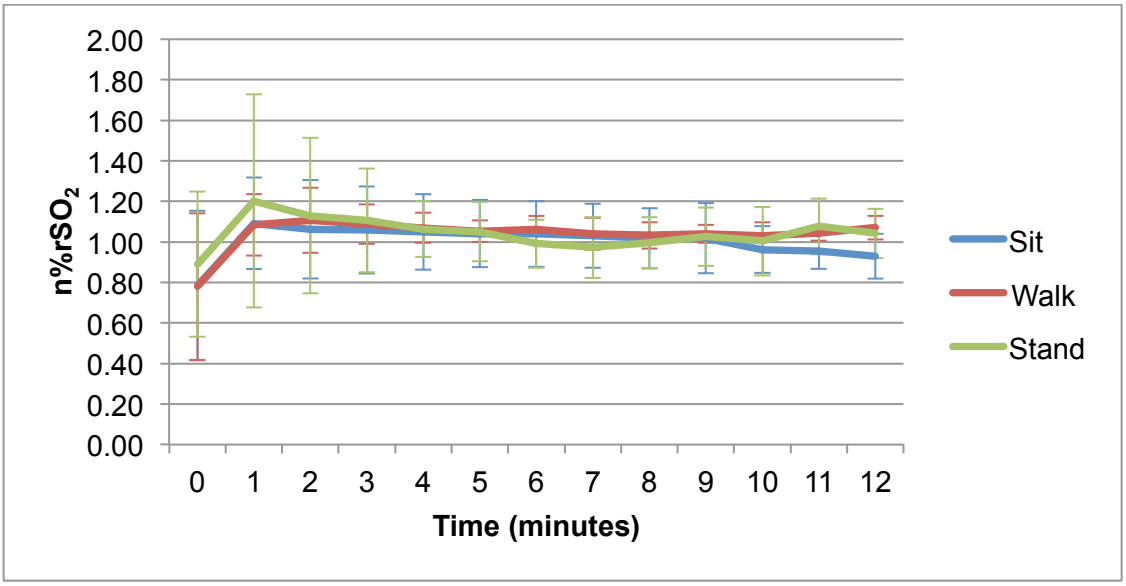

Figure 12: Normalized %rSO_2 values over time for MG muscle

3.1.1 Tibialis Anterior Muscle

A large variation was seen in the time to return to pre-kneeling baseline rSO_2 values for all the post-kneeling tasks. The walking task seems to have the fastest time for rSO_2 recovery, with an average of 3.95(±2.91) minutes (Figure 11). Nevertheless

large variations were seen for walking that ranged between 1 to 11 minutes. Ten (52%) of the subjects' rSO_2 levels recovered to the pre-kneeling baseline within the first 3 to 3.5 minutes. Only one subject's rSO_2 levels returned to the pre-kneeling level after 10 minutes of walking.

The sitting post-kneeling task was the next fastest with an average time of 4.32(3.18) minutes (Figure 13) to return to the pre-kneeling baseline rSO_2. The time ranged between 1 and 12 minutes with the majority of subjects (14 of 19) recovering to their pre-kneeling baseline rSO_2 level within 5 minutes of sitting down, and only one subject was recovering for 12 minutes.

The longest time to return to pre-kneeling baseline rSO_2 levels was observed during the standing post-kneeling task, with an average time of 5.16(3.32) minutes (Figure 13), and times ranging between 1 and 12 minutes. It took over 10 minutes for 3 subjects to recover to their pre-kneeling rSO_2 level while standing still.

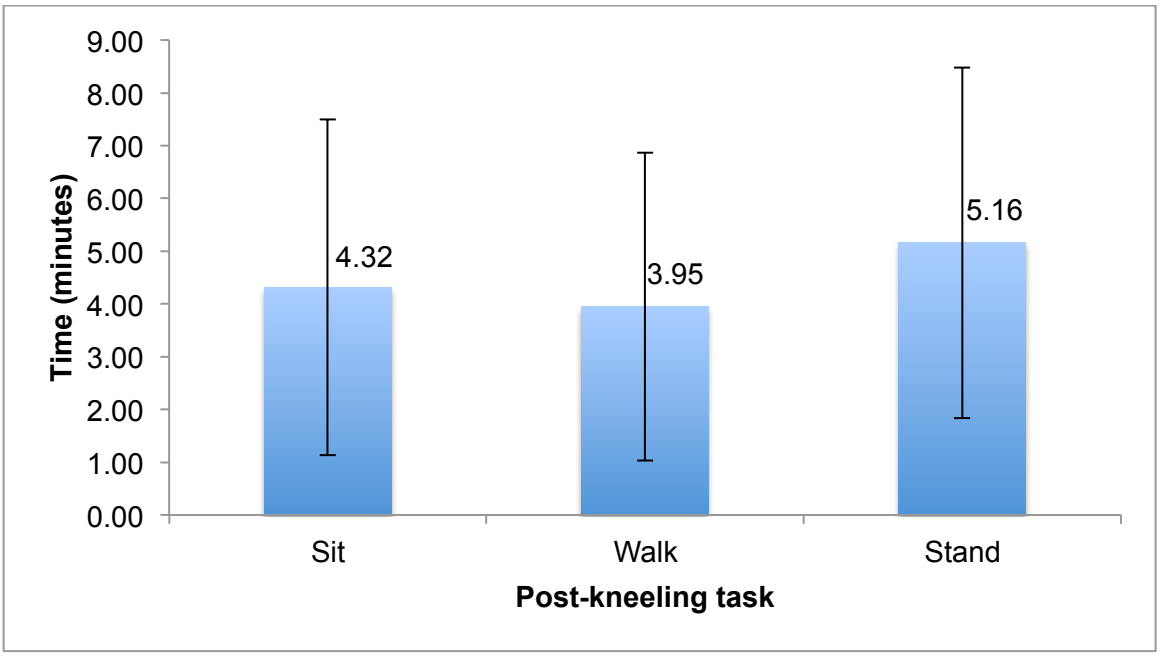

Figure 13: The average time of recovery in TA for each post-kneeling task

Rate of recovery results were different from the time to recover results. The fastest recovery rates (Figure 14) were observed during the post-kneeling sitting task, with an average of 15.12(16.06) %rSO_2 per minute, followed by walking with an average of 13.89(14.45) %rSO_2 per minute. Standing was found to have the slowest rate of recovery, gaining only 9.25(11.50) %rSO_2 per minute. There was a high variation in the rate of recovery, with values ranging anywhere from 46.6% rSO_2 per minute to no return to pre-kneeling baseline values after 15 minutes of performing a post-kneeling task.

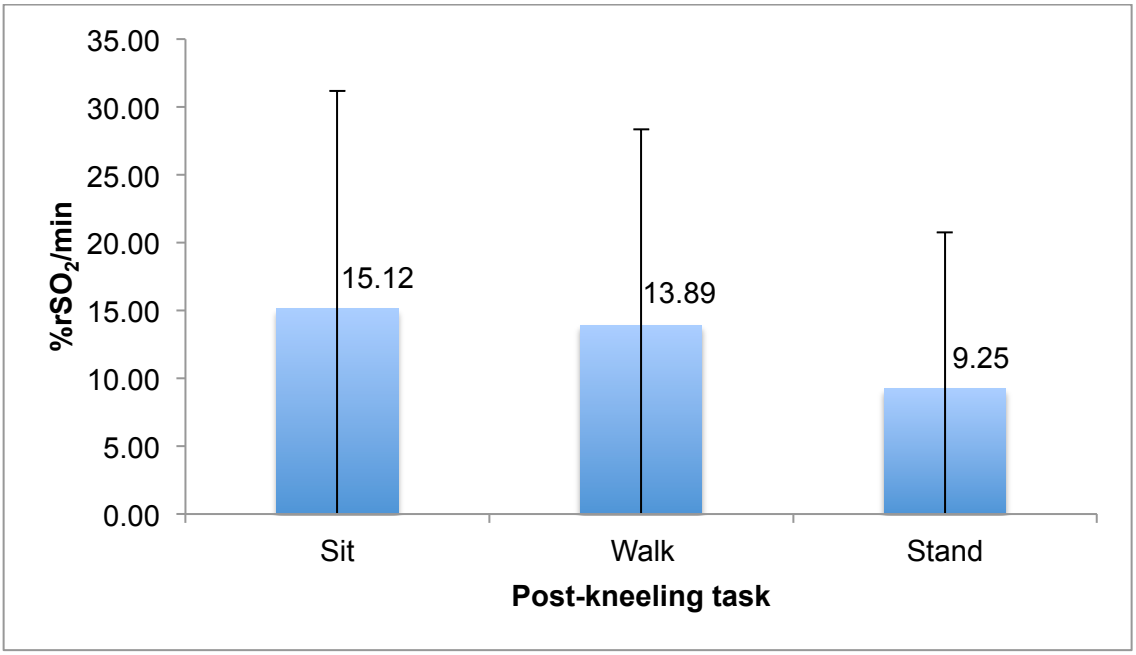

Figure 14: The average rate of rSO_2 recovery in TA for each post-kneeling task

Survival analysis found that in about 7 minutes there is an 90% chance that the subject will return to their pre-kneeling rSO_2 level while sitting, 95% while walking, and 74% while standing (Figure 15). The chance of rSO_2 return to pre-kneeling baseline while sitting by 2 minutes is 36.84%, by 4 minutes the chance is 63%, and it reached

95% probability by 9 minutes. For the walking task, the chance of returning to pre-kneeling values by 2 minutes is 36.84%, and reached 95% probability by 5 minutes. As for the standing task, the chance of returning to pre-kneeling baseline values by 2 minutes was only 26.32%, the probability reached 50% by 4 minutes of standing, and at 11 minutes the probability became 95%.

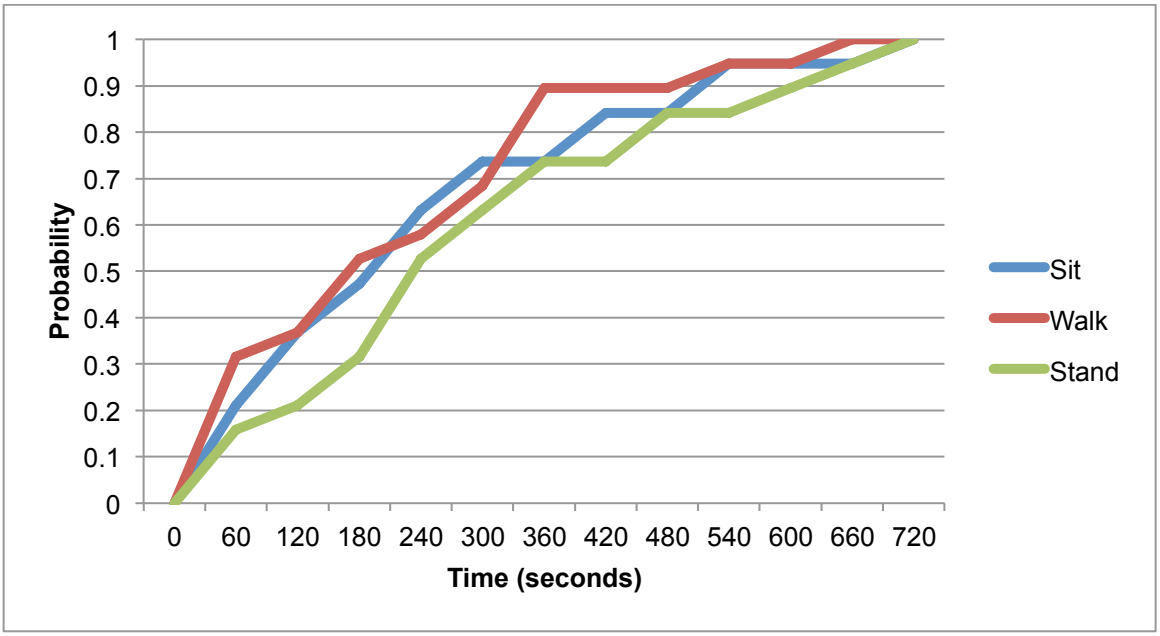

Figure 15: Survival analysis for time for rSO2 level recovery in the TA

3.1.2 Medial Gastrocnemius Muscle

Overall the MG muscle was faster to return to pre-kneeling rSO_2 level (Figure 16) for all post-kneeling tasks compared to the TA muscle. Sitting was found to have the shortest time for rSO_2 levels to recover to the pre-kneeling baseline, with an average of 2.84(2.46) minutes, and times ranging from 1 to 9 minutes. All subjects' rSO_2 levels returned to their pre-kneeling values before 10 minutes of sitting, and 16 out of the 19 subjects showed recovery within 5 minutes.

The walking post-kneeling task resulted in an average of 3.16(2.48) minutes for rSO_2 levels to return to the pre-kneeling baseline. The majority (16 of 19) of the subjects' rSO_2 levels in the MG muscle recovered to their pre-kneeling baseline values within the first 5 minutes. The remaining three subjects' rSO_2 values recovered within 9 minutes. Overall, the time for MG muscle rSO_2 levels to recover to the pre-kneeling baseline while walking varied from 1 to 9 minutes.

The slowest post-kneeling rSO_2 recovery for the MG muscle was seen during standing, with an average of 4.58(3.59) minutes and times ranging from 1 to 12 minutes. Only one subject exhibited slow recovery (12 minutes), while ten subjects' rSO_2 levels returned to their baseline within the first 5 minutes.

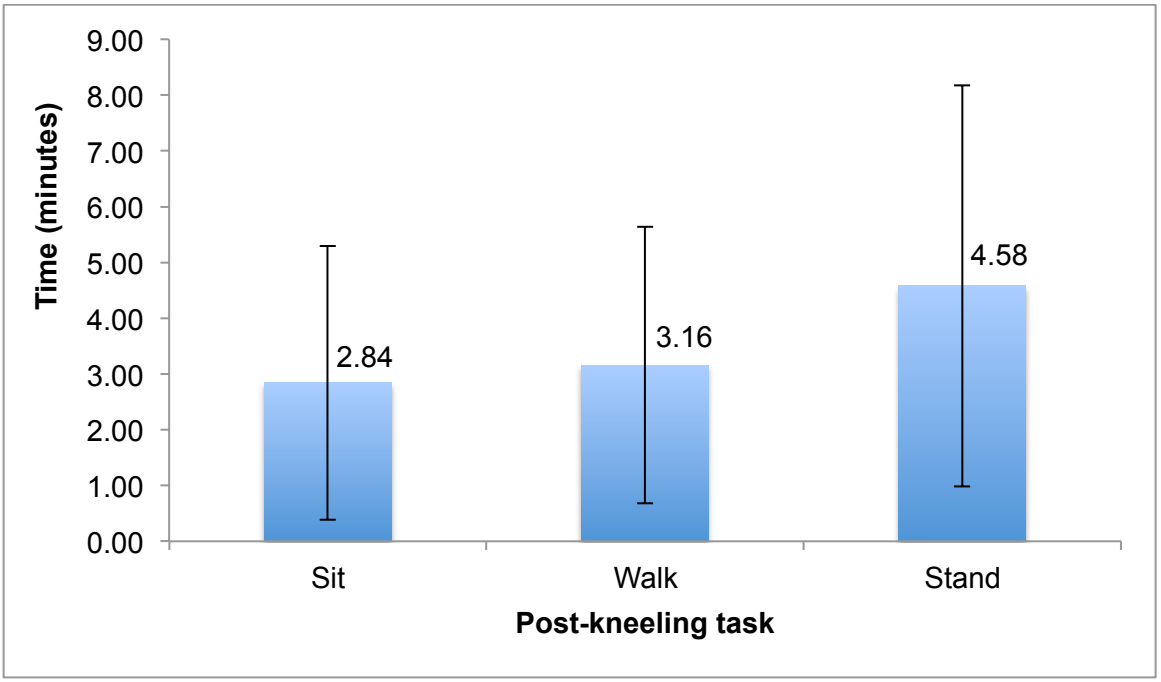

Figure 16: The average time of recovery in MG for each post-kneeling task

Rate of rSO_2 recovery rate (Figure 17) again showed a large variation, with the fastest rate seen during the sitting task, with an average value of 14.64(13.86) $\%rSO_2$

per minute. The walking post-kneeling task had a similar rate, with an average value of 13.31(17.06) %rSO_2 per minute. As for the standing task, the average rate of recovery was 9.39(12.83) %rSO_2 per minute. The values ranged from no need to return to pre-kneeling baseline values to 50.4 %rSO_2 per minute, which was also the greatest variability among the tasks.

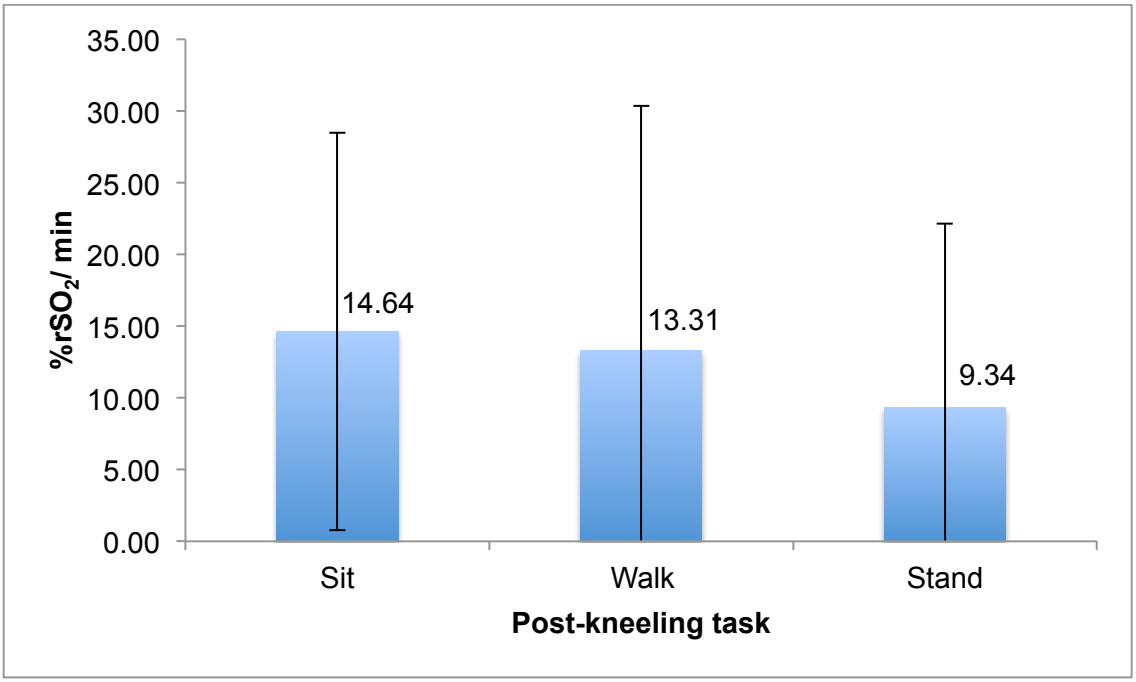

Figure 17: The average rate of rSO_2 recovery in MG for each post-kneeling task

The survival analysis revealed that in 9 minutes there is a 94.7% chance that the subjects will return to their pre-kneeling conditions while sitting and walking. As for standing, the probability for the MG muscle to recover to its pre-kneeling baseline in 9 minutes was 95% (Figure 18). The chances for this muscle to return to its pre-kneeling baseline values while walking are the following: 1 minute-42.11%; 2 minutes-47.37%; 3 minutes-63.13%; 4 minutes-73.68%; 5 minutes-84.21%; and a 95% chance by 6 minutes. For the sitting post-kneeling task, the probabilities are the following: 1 minute-

31.58%; 2 minutes-68.42%; 3 minutes-78.95%; 4 minutes-84.21%; and a probability of 95% by 6 minutes. As for the standing task, lower probabilities are seen, and by 1 minute the probability is 31.58%, it reaches 52% by 3 minutes, and at 6 minutes the chance only increases by 10%, becoming 63% and by 9 minutes there is a 95% change of returning to pre-kneeling baseline values.

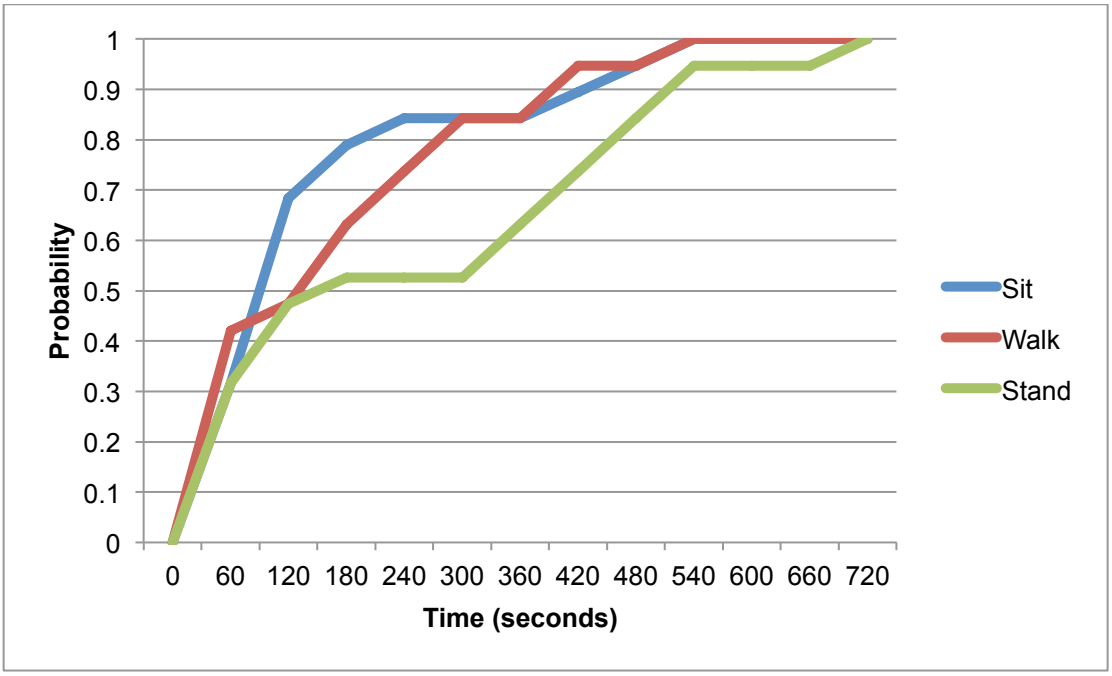

Figure 18: Survival analysis for time to of rSO_2 level recovery in the MG

Overall, Table 3 shows the time it takes a muscle to return to its pre-kneeling baseline condition with 50% and 95% confidence for all three post-kneeling tasks. In this case, overall the LMG returns to its baseline value before the LTA. Additionally, looking at the overall results, the post-kneeling tasks that are the fastest to return to their pre-kneeling baseline values are the walking and sitting tasks.

Table 3: Time (seconds) at which muscle will return to pre-kneeling baseline conditions with a 95% and (50%) confidence

Muscle	50% and 95% confidence recovery time (seconds)					
	Sit		Walk		Stand	
	50%	95%	50%	95%	50%	95%
TA	180	540	180	540	240	660
MG	100	480	120	420	180	540

. An ANOVA was run using the recovery times at each recovery probability, considering muscle type and recovery tasks as the main factors The ANOVA results (at $\alpha = 0.05$) indicate that the for the 50% recovery times, post kneeling task was {indicate significance and p-value in parenthesis}, while the muscle type was {indicate significance and p-value in parenthesis}. On the other hand, the results for the 95% recovery times (at $\alpha = 0.05$) indicate that the for the 50% recovery times, post kneeling task was {indicate significance and p-value in parenthesis}, while the muscle type was {indicate significance and p-value in parenthesis}. Interaction plots were constructed to determine if the recovery times for each muscle type were significantly affected by the post-kneeling tasks. The expectation was for the lines of the muscles and the tasks to be parallel—indicating a lack of interaction. The 95% recovery probability times plot (Figure 19) indicate no significant interaction between the task and the muscle type. However, for the 50% recovery times (Figure 20) there was a slight significant interaction between muscle type and the sit and walk tasks. Overall is appears that the MG muscle recovered faster across all tasks while the walking task resulted in faster recovery for both muscle types.

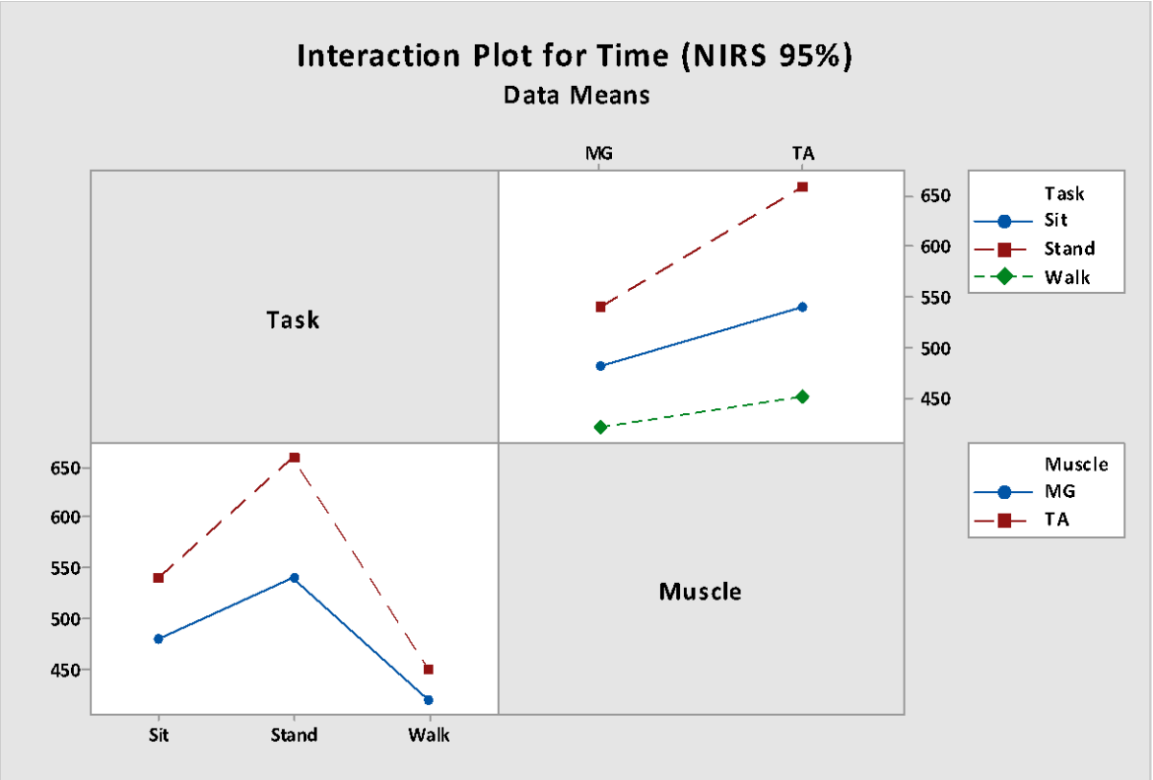

Figure 19: Interaction plot for time for NIRS recovery (95% probability)

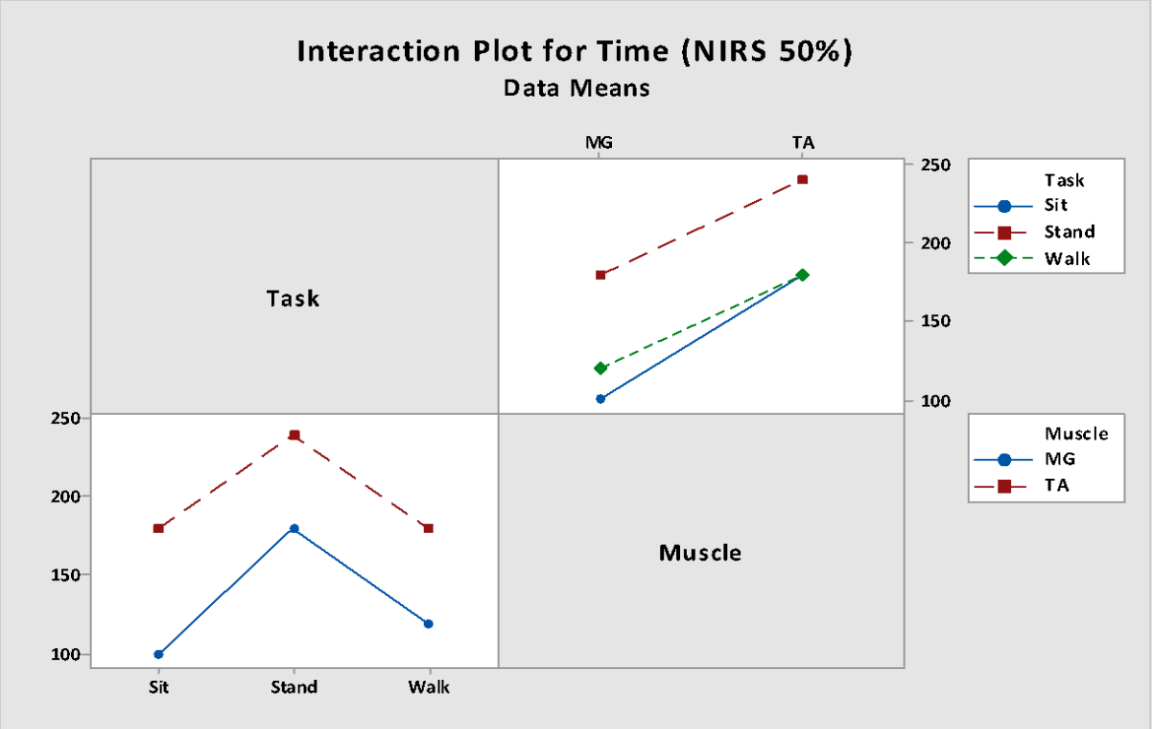

Figure 20: Interaction plot for time for NIRS recovery (50% probability)

3.2 Muscle Activity

3.2.1 RMS

Time to return to pre-kneeling baseline values for RMS and MDF ranged from 0 to 3 minutes for all muscles and all post kneeling tasks (Appendix D). Overall, the walking post-kneeling task showed the shortest time to return to pre-kneeling baseline values, while standing had the longest time.

All ten muscles exhibited different times to return to pre-kneeling baseline values for the RMS (Figure 22). The sitting task was the fastest to recover for the RVL, LRA, LES, and RVM muscles with an average of 0.94(±0.57), 1.00(±0.49), 1.06(±0.25), 1.19(±0.91) minutes respectively.

The walking task returned to pre-kneeling baseline values the fastest, as compared to the other post-kneeling tasks, for the RTA, RMG, and RES, with average times of 1.06(±0.54), 0.64(±0.63), and 1.11(±0.58) respectively. The muscles that returned to pre-kneeling baseline values the fastest when utilizing the standing post-kneeling task were RGL, RRA, and RRF, with average times of 1.06(±1.00), 1.11(±0.90), and 1.06(±0.73) minutes respectively.

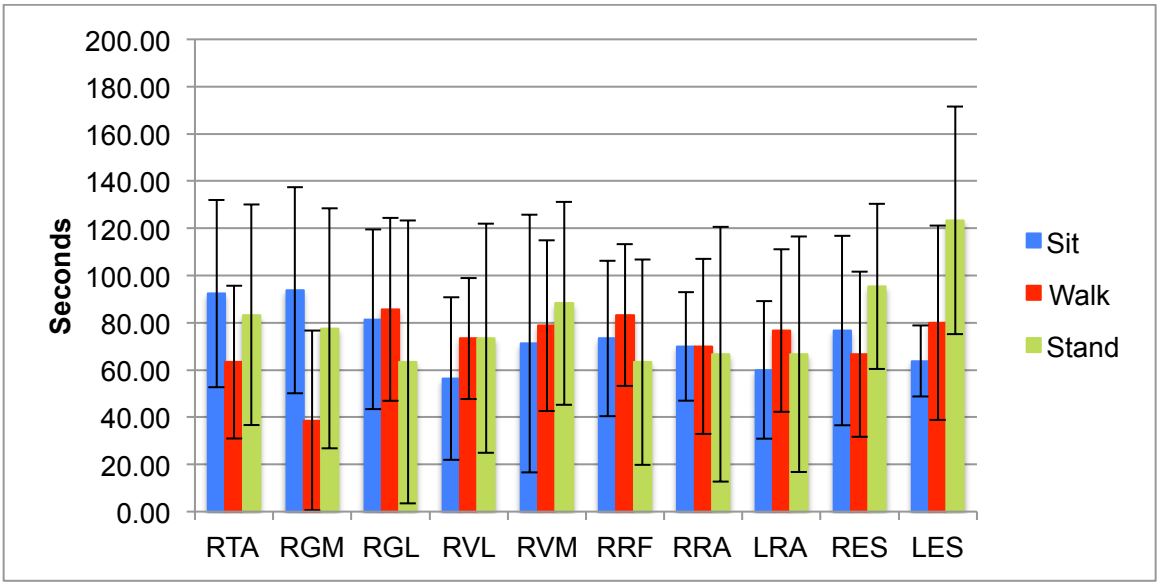

Figure 21: RMS time to return to pre-kneeling baseline values for all post-kneeling tasks

The rate of recovery followed the same pattern for all muscles and all tasks, a sharp decrease during the first 30 seconds of the post-kneeling segment followed by a stabilization of the values.

3.2.1.1 RVL Muscle

3.2.1.1.1 Rate of Recovery

On average the RVL (Figure 22) muscle RMS returned to the pre-kneeling baseline value at 70 seconds for all 3 post-kneeling tasks. In general, the walking and standing tasks had the fastest rates of recovery; however variations between the tasks were greater during the first seconds post-kneeling. ANOVA found that the differences between the rates of recovery for this muscle were not statistically significant with a *p-value* of 0.434.

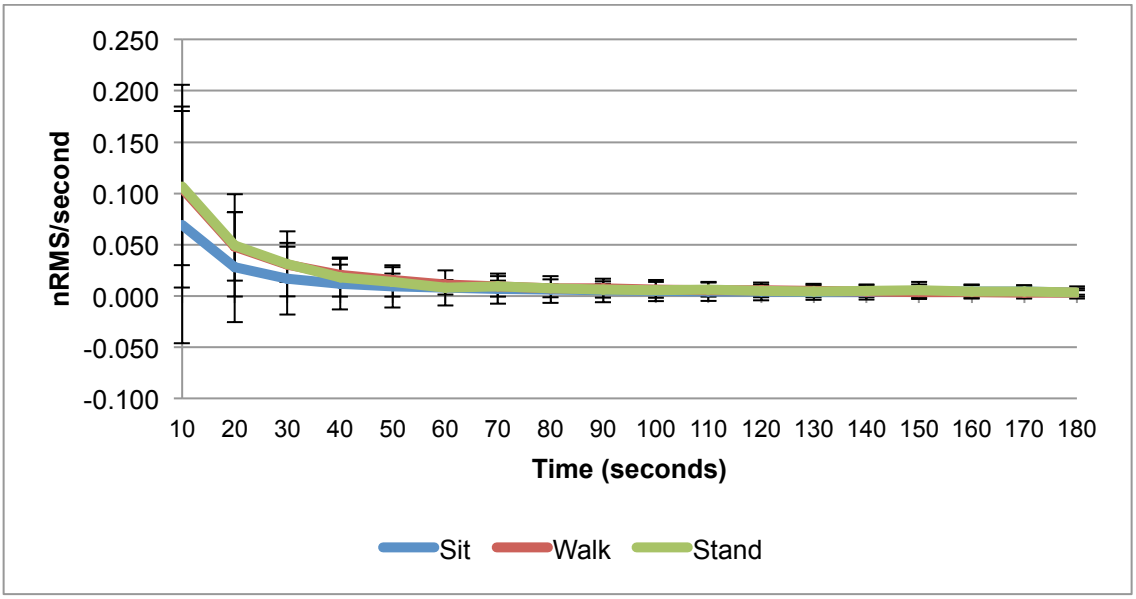

Figure 22: RMS rate of recovery for the RVL muscle

3.2.1.1.2 Survival Analysis

Survival analysis for the RVL muscle (Figure 23) showed that the sitting task reached 100% by 90 seconds, while walking did at 120 seconds, and standing at 130 second, which may indicate that for this muscle sitting would be the most efficient task for recovery after prolonged kneeling in full knee flexion.

The differences between the post-kneeling tasks were not statistically significant, between each other.

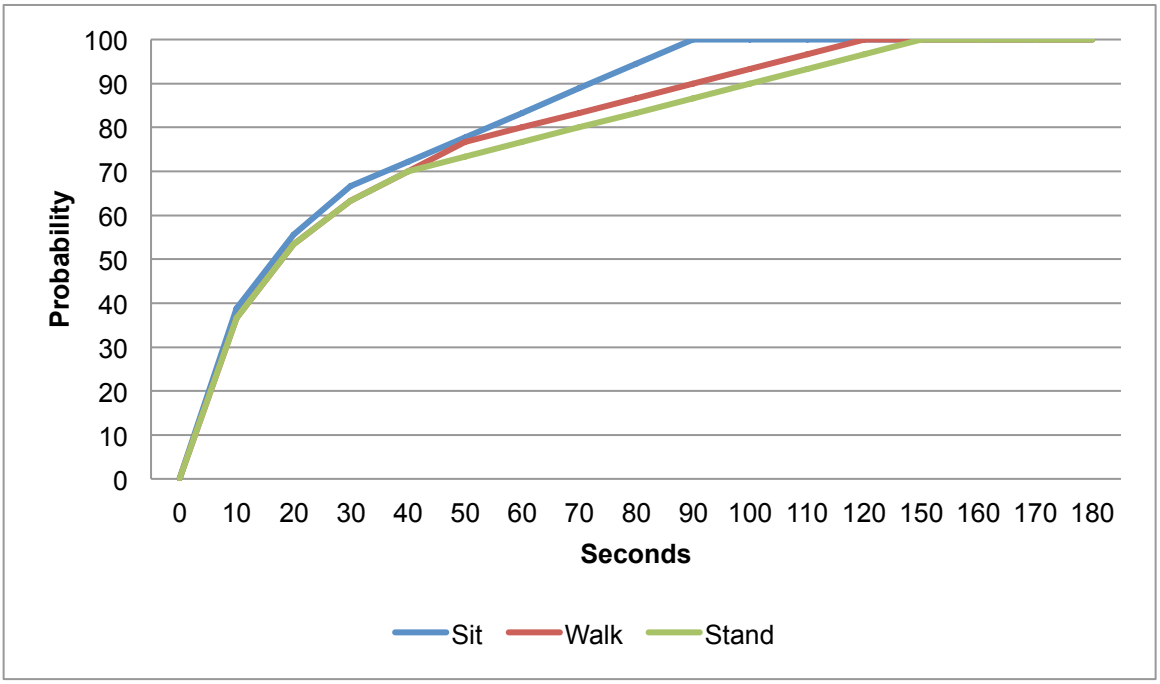

Figure 23: Survival analysis for the RMS rate of recovery values for the RVL muscle

3.2.1.2 RTA Muscle

3.2.1.2.1 Rate of recovery

For the RTA muscle (Figure 24) sitting and standing showed the steepest decrease in rate of recovery, while for walking it was seen that on average the muscle was already within pre-kneeling baseline values at the start of the post-kneeling section. This may indicate that, for the walking trials, on average the muscle did not reach a sufficient level of fatigue to produce changes in the EMG RMS levels. Even though walking appears to be different from sitting and standing, variability is large enough for the difference not to be statistically significant with a *p-value* of 0.210.

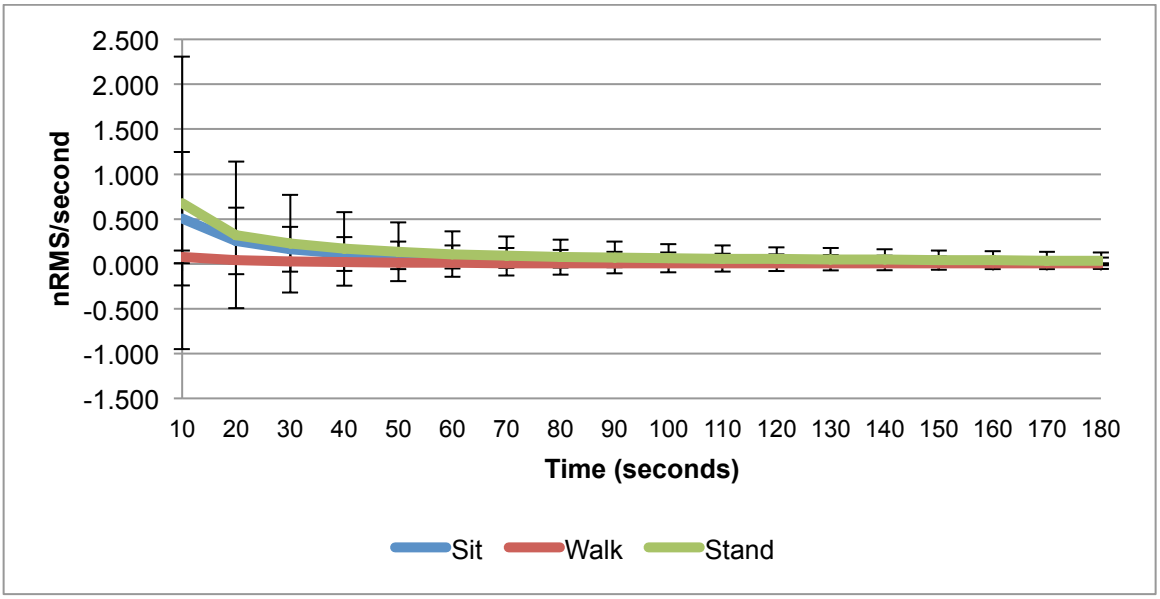

Figure 24: RMS rate of recovery for the RTA muscle

3.2.1.2.2 Survival Analysis

Survival analysis for the RTA muscle (Figure 25) showed that there is a almost no difference between the post-kneeling tasks, with sitting and standing reaching 100% at 180 seconds and walking at 140 seconds. The differences were not statistically significant.

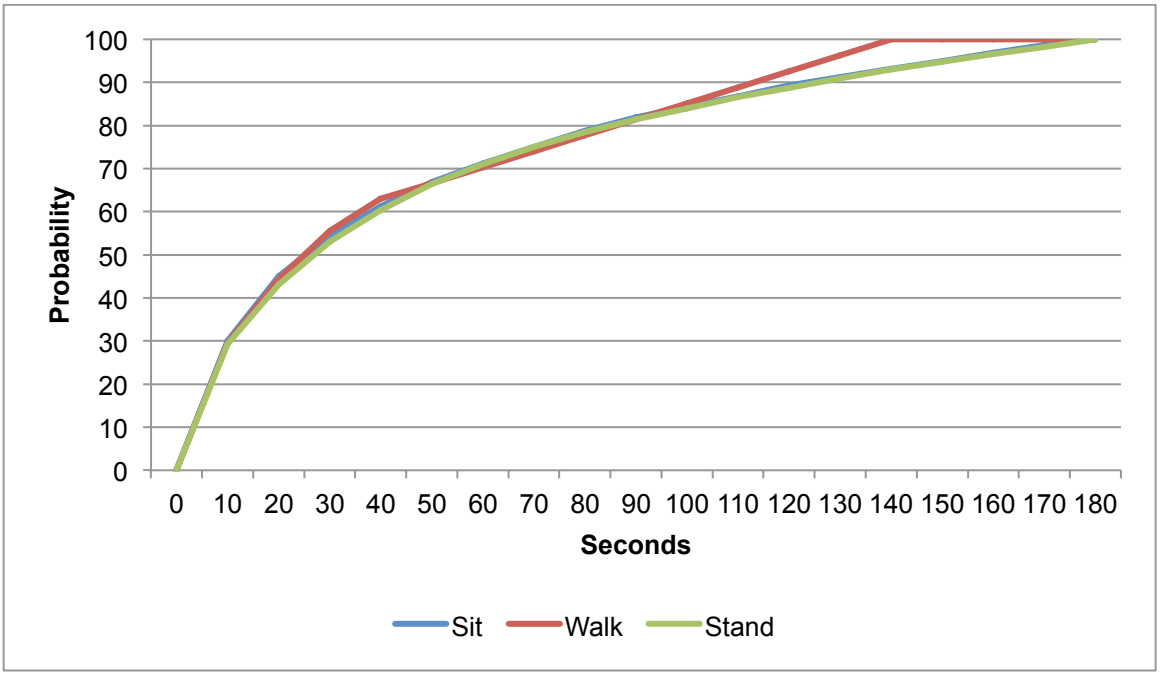

Figure 25: Survival analysis for the RMS rate of recovery values for the RTA muscle

3.2.1.3 RGM and RGL Muscles

3.2.1.3.1 Rate of Recovery

All the post-kneeling tasks for the RGM (Figure 26) and RGL (Figure 27) muscles exhibited a similar rate of recovery slope, with the walking task having the sharpest decrease in rate. The sitting task reached the pre-kneeling baseline value at 70 seconds, while the walking and standing tasks did not reach the pre-kneeling baseline values until 110 seconds. For the RGM and RGL muscles ANOVA showed no statistical significance between the post-kneeling tasks, with p-values of 0.651, and 0.143 respectively.

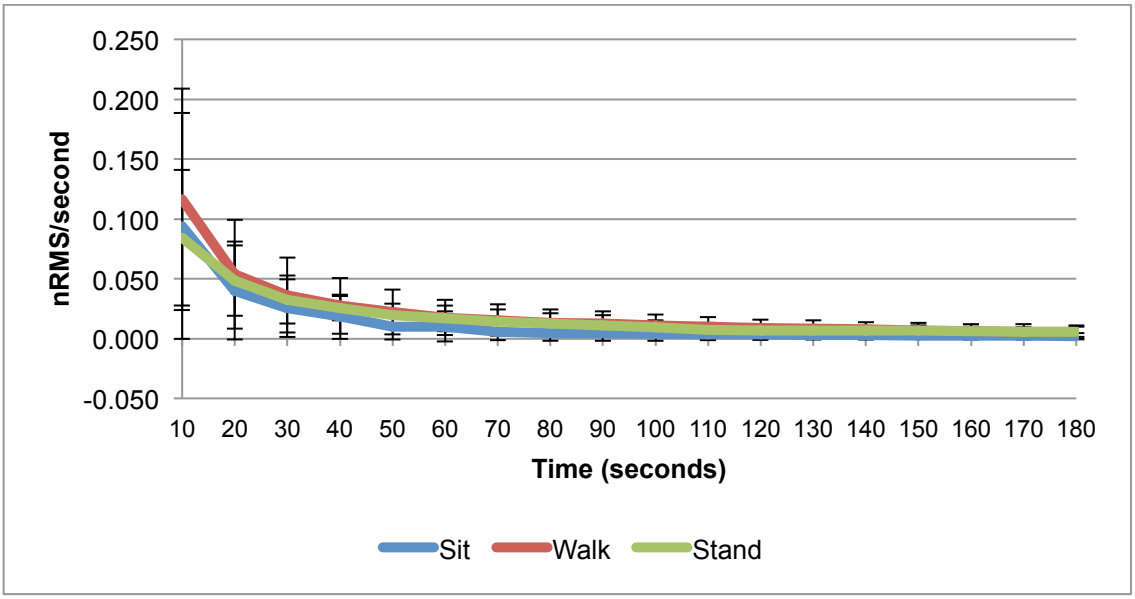

Figure 26: RMS rate of recovery for RGM muscle

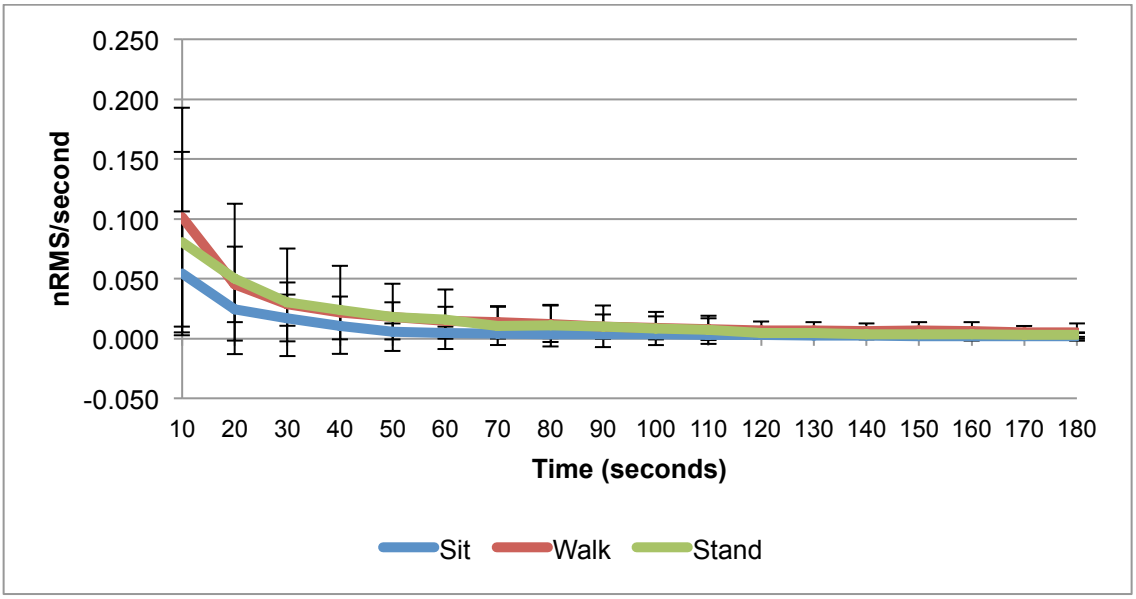

Figure 27: RMS rate of recovery for the RGL muscle

3.2.1.3.2 Survival Analysis

The survival analysis plot for the RGM (Figure 28) showed that sitting condition reaches 100% by one minute of sitting, while for walking and stating it requires 3 minutes. The difference between sitting and walking tasks was statistically significant

with a *p-value* of 0.0054; as well as the difference between sitting and standing task (*p-value*=0.0017). Survival analysis for the RLG (Figure 29) shows that sitting task reaches 100% by 50 seconds, walking by 180 seconds, and standing by 110 seconds. Sitting and walking, as well as walking and standing, were found to be statistically significant with *p-values* of 0.0106 and 0.0314 respectively.

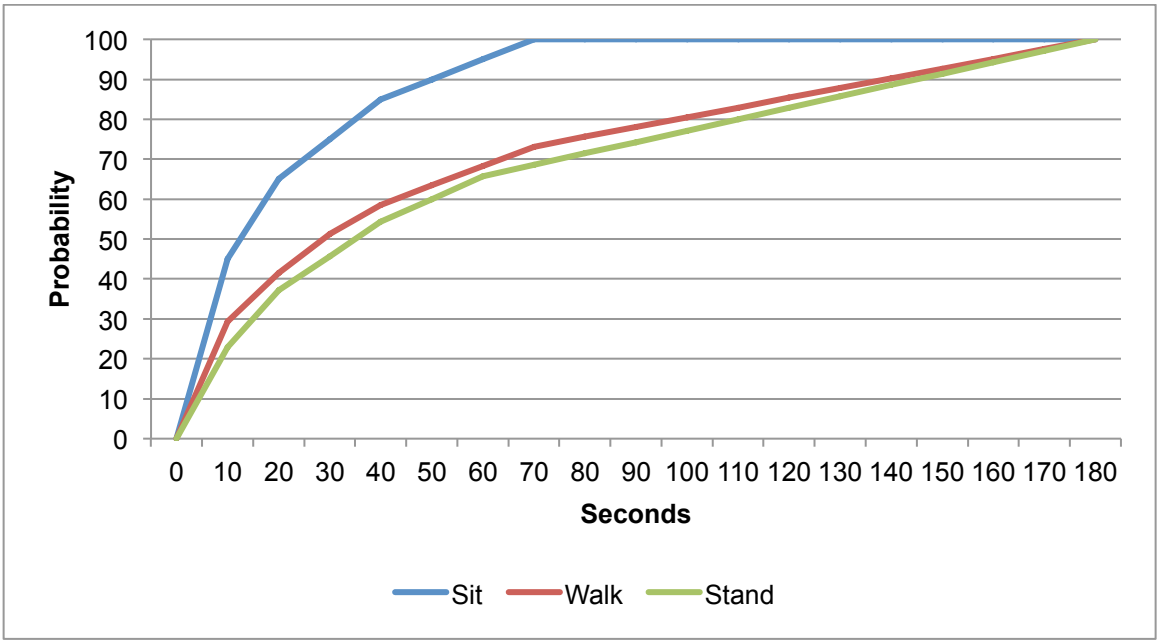

Figure 28: Survival analysis plot for the rate of recovery values of RMS for the RGM muscle

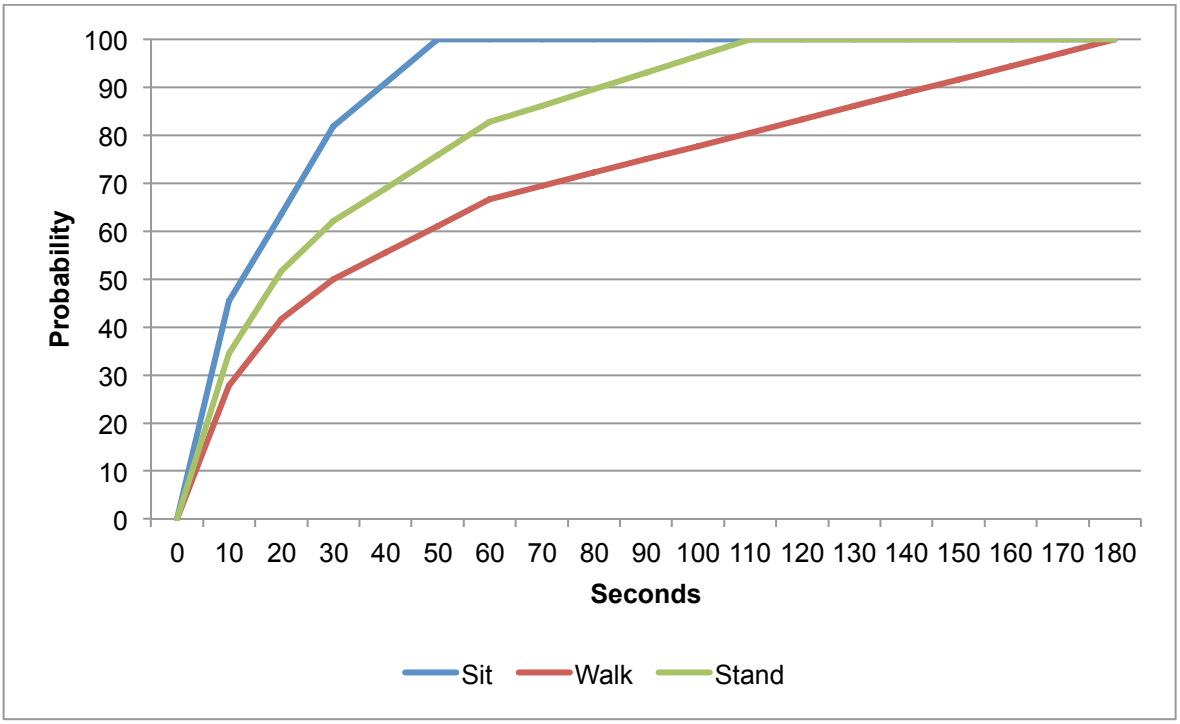

Figure 29: Survival analysis plot for the rate of recovery values for RMS for the RGL muscle

3.2.1.4 RRA and LRA Muscles

3.2.1.4.1 Rate of Recovery

Analysis of the abdominal muscle (RRA and LRA) results (Figures 30 and 31) showed that the standing task had the slowest rate of recovery while the sitting task had the sharpest decrease in rate. For the RRA muscle, the three post-kneeling tasks followed a similar slope. However, for the LRA muscle the standing task had a slower rate of recovery. The RRA and LRA rates of recovery had no statistically significant difference with *p-values* of 0.733 and 0.549 respectively.

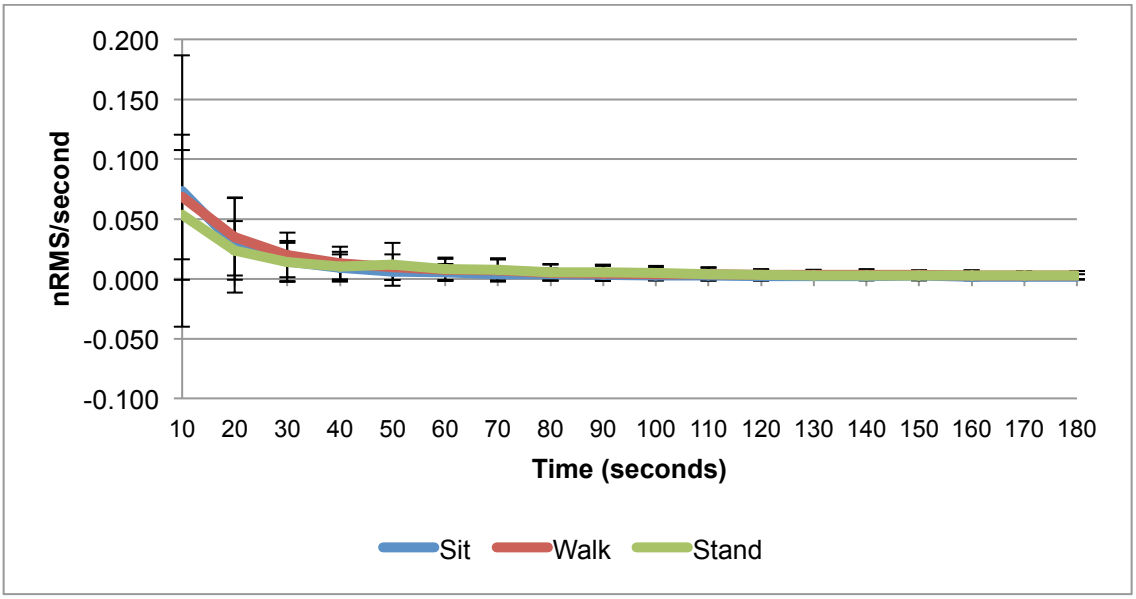

Figure 30: RMS rate of recovery for the RRA muscle

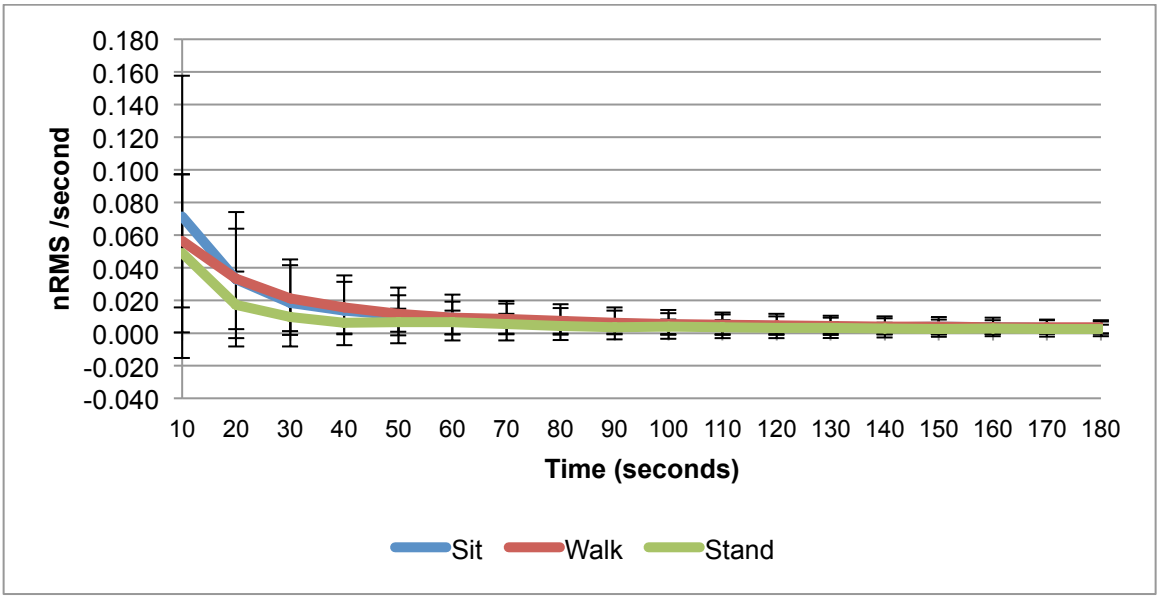

Figure 31: RMS rate of recovery for the LRA muscle

3.2.1.4.2 Survival Analysis

According to the survival analysis for the RRA muscle, for all conditions it reached 100% between 60 and 90 seconds, the difference between the tasks was not statistically significant. For this muscle the probabilities for returning to baseline values

are close to each other for all tasks, which may indicate that regardless of which task is performed, the muscle will return to its pre-kneeling baseline values at about the same time. The LRA muscle had a range of 70 to 110 seconds, the differences between the post-kneeling tasks were also not statistically significant.

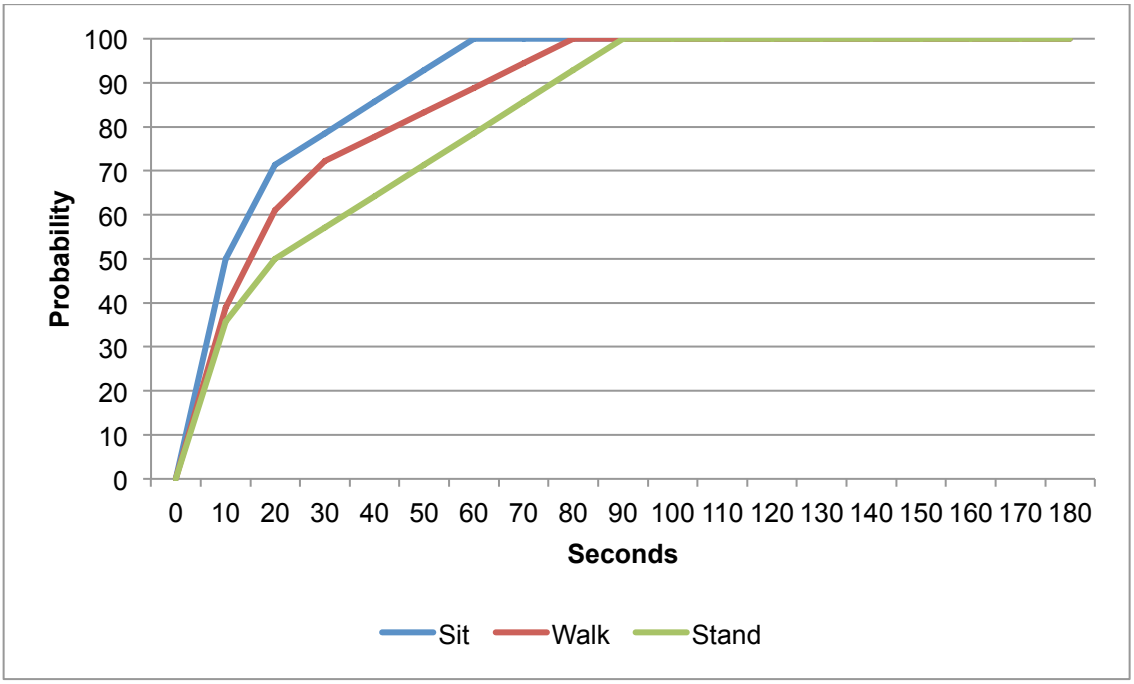

Figure 32: Survival analysis plot for the rate of recovery values for RMS for the RRA muscle

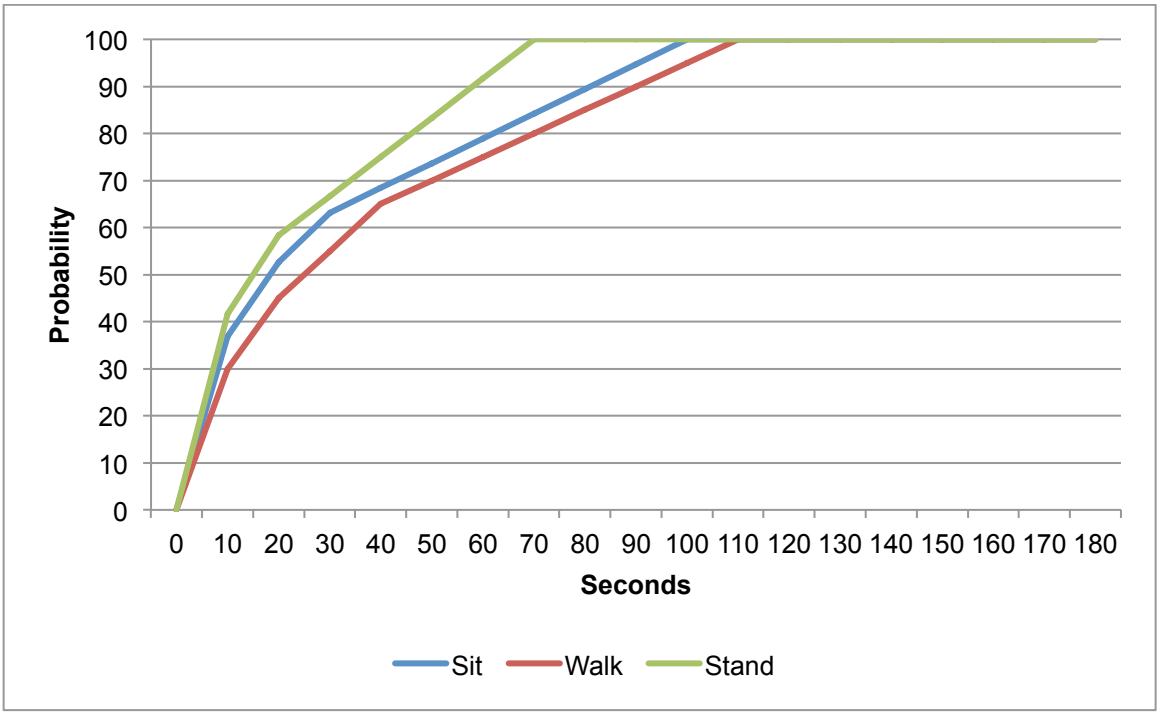

Figure 33: Survival analysis plot for the rate of recovery values for the RMS of the LRA muscle

3.2.1.5 RES and LES Muscles

3.2.1.5.1 Rate of Recovery

The back muscles (RES and LES) (Figures 34 and 35) followed a similar pattern to the abdominal muscles regarding rate of recovery. The sitting task had the steepest decrease, showing the fastest recovery rate, followed by the standing task, and the walking task with the slowest recovery rate. Statistical analysis showed that the differences between post-kneeling tasks were statistically significant for the RES but not for the LES. The RES muscle had a *p-value* of 0.035 and the Tukey test indicates that sitting is statistically significant different from walking but not standing. The LES had a *p-value* of 0.079.

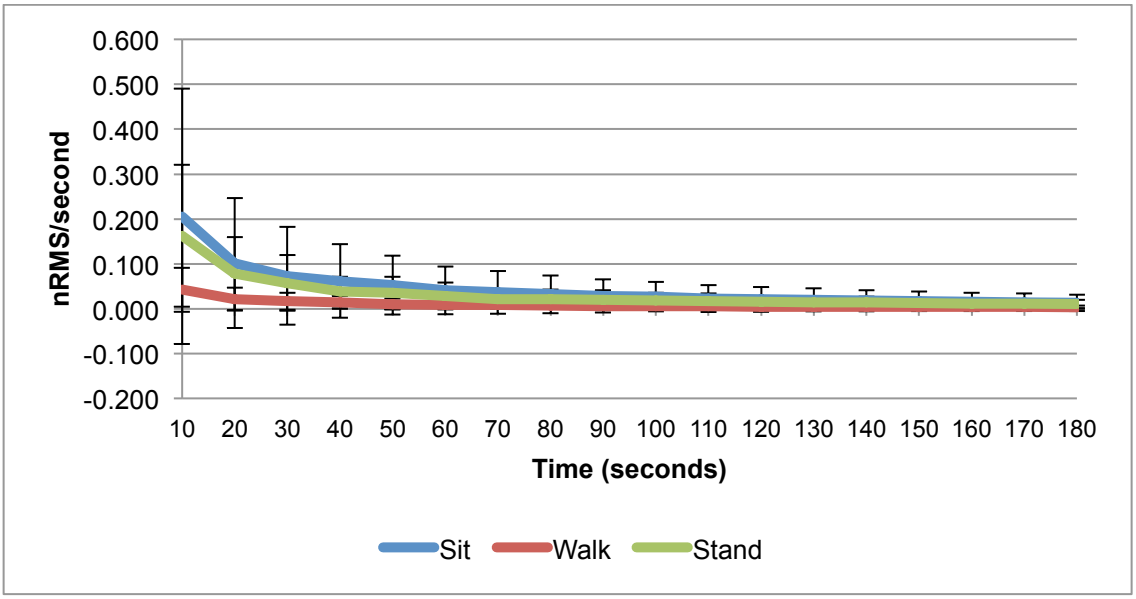

Figure 34: RMS rate of recovery for RES muscle

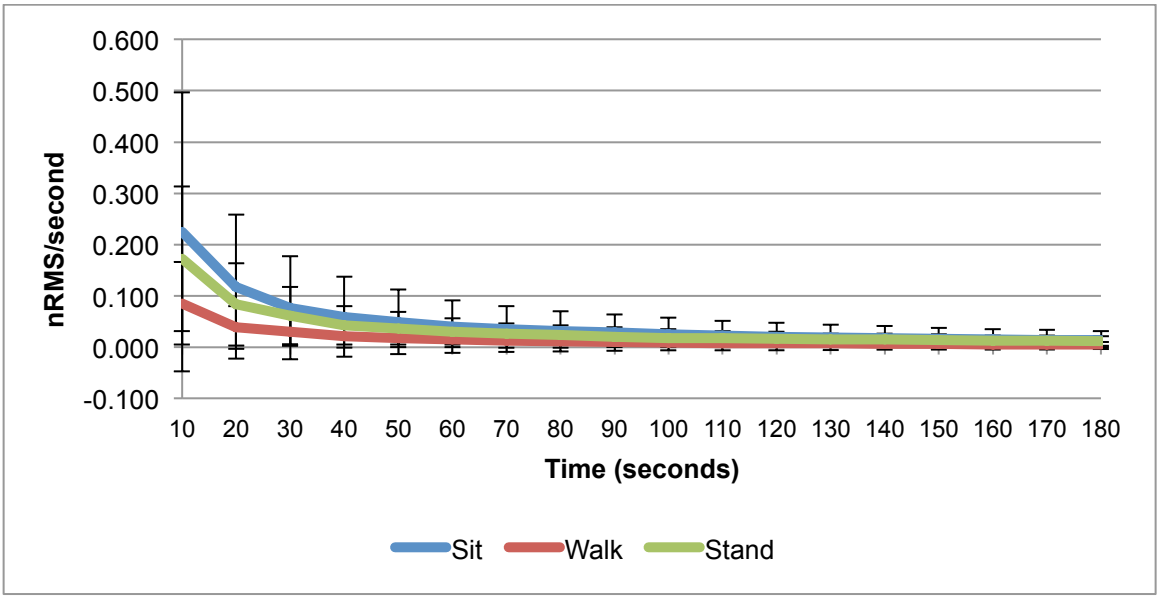

Figure 35: RMS rate of recovery for LES muscle

3.2.1.5.2 Survival Analysis

For the RES muscle walking task was the fastest reaching 100% at 110 seconds, while for sitting and standing it required 180 seconds. The differences were not

statistically significant. As for the LES muscle, all post-kneeling tasks reached 100% by 180 seconds. For both muscles the tasks were very close to each other with no evident difference between them.

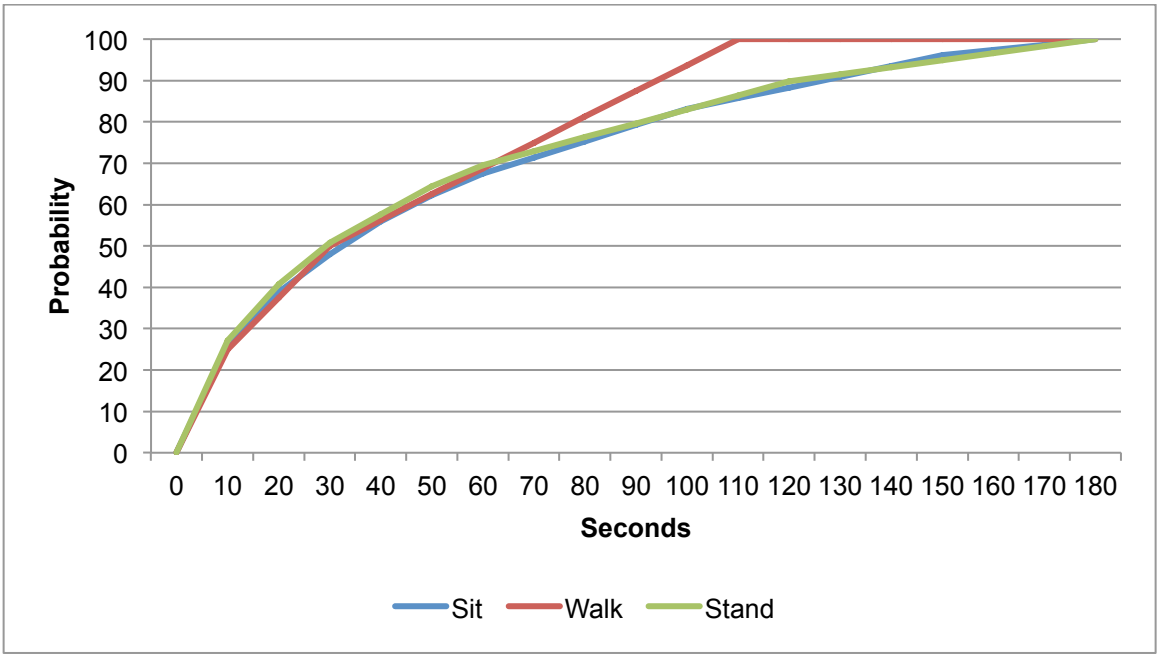

Figure 36: Survival analysis plot for rate of recovery values for RMS for the RES muscle

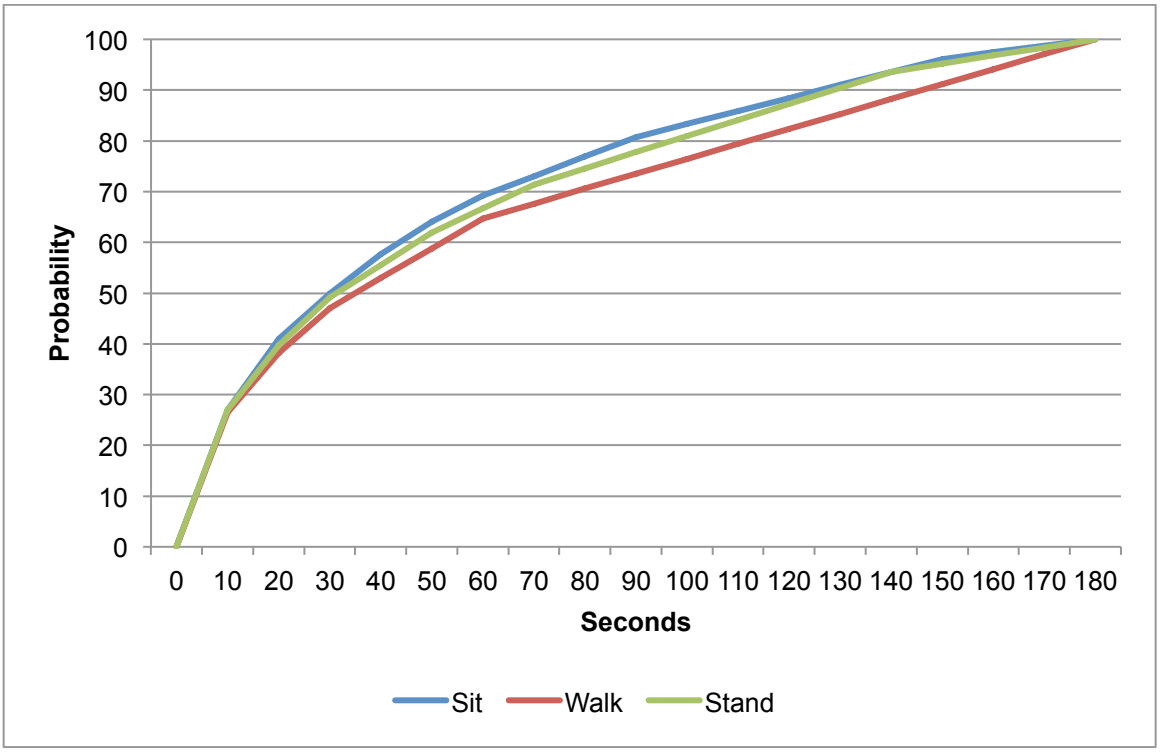

Figure 37: Survival analysis plot for the rate of recovery value for the RMS of the LES muscle

3.2.1.6 RVM Muscle

3.2.1.6.1 Rate of Recovery

For the RVM (Figure 38) muscle, the sitting and standing tasks had similar slopes for recovery rate, with the sharpest decreases seen during the first 10 seconds. The walking task had the slowest rate of recovery. However, on average, all three tasks showed similar results with a muscle activity, reaching the pre-kneeling baseline value around 90 seconds into the post-kneeling section. No statistically significant difference was found for this muscle (*p-value*=0.360).

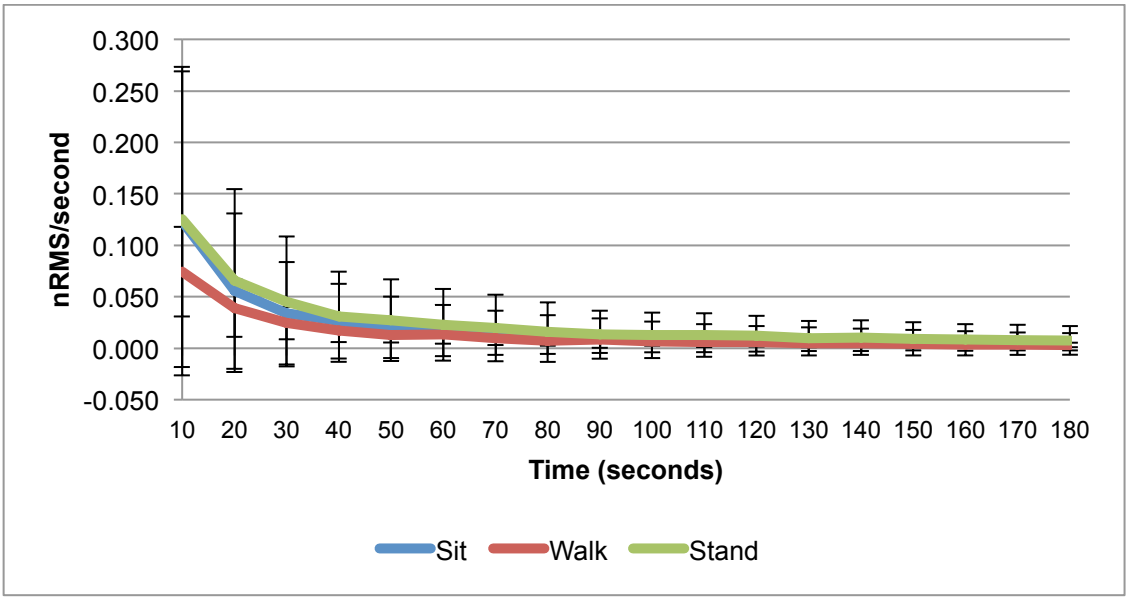

Figure 38: RMS rate of recovery for the RVM muscle

3.2.1.6.2 Survival Analysis

Survival analysis showed that the sitting and standing tasks need 180 seconds to reach 100%, while walking only required 120 seconds. The differences between the post-kneeling tasks were not statistically significant.

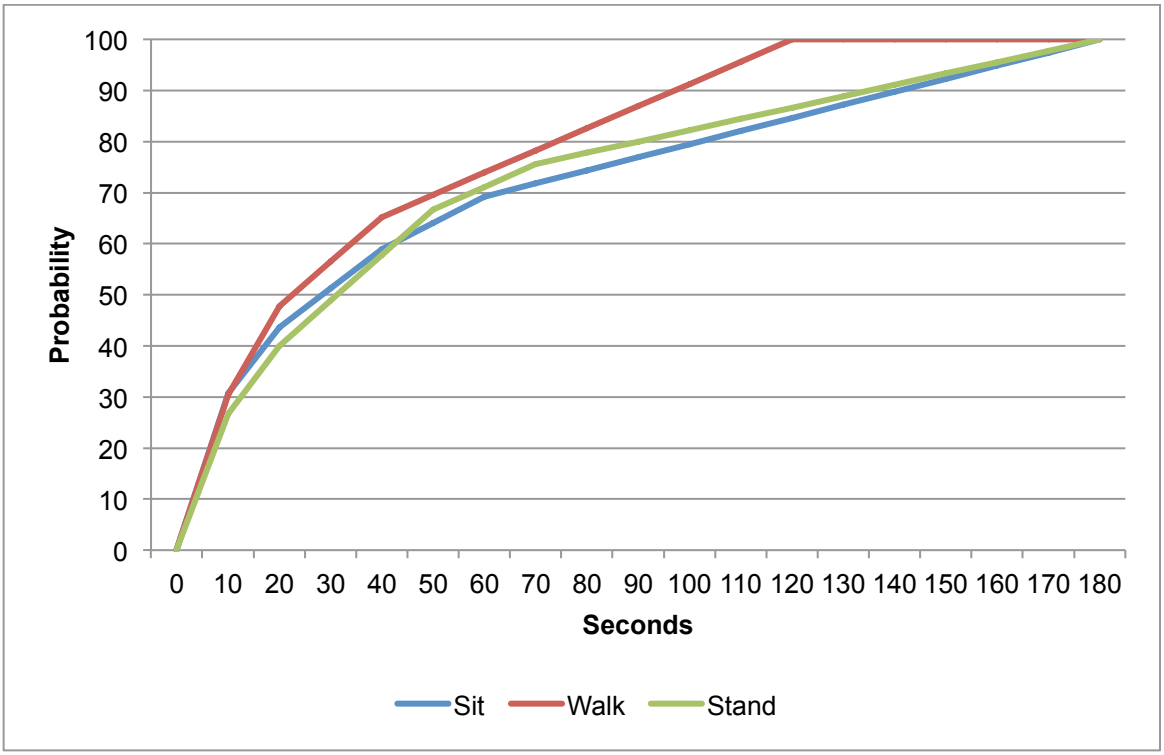

Figure 39: Survival analysis plot for rate of recovery values for the RMS of the RVM muscle

3.2.1.7 RRF Muscle

3.2.1.7.1 Rate of Recovery

The RRF muscle (Figure 40) followed the same slopes in recovery rate for all three post-kneeling tasks, with the sharpest decreases during the first 30 seconds of the trial and reaching the pre-kneeling baseline value at 90 seconds. The ANOVA showed no statistical significance between the post-kneeling tasks (*p-value*=0.826).

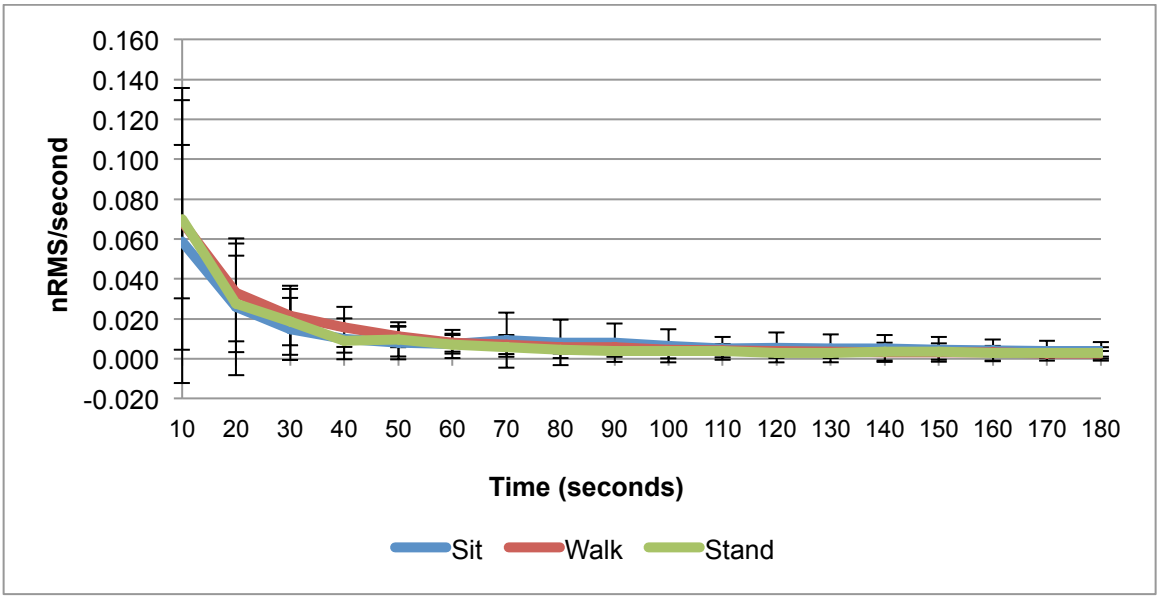

Figure 40: RMS rate of recovery for the RRF muscle

3.2.1.7.2 Survival Analysis

Survival analysis showed that for the RRF muscle there is a statistically significant difference between sitting and standing task, with a p-value of 0.0329, while not for the other task comparisons.

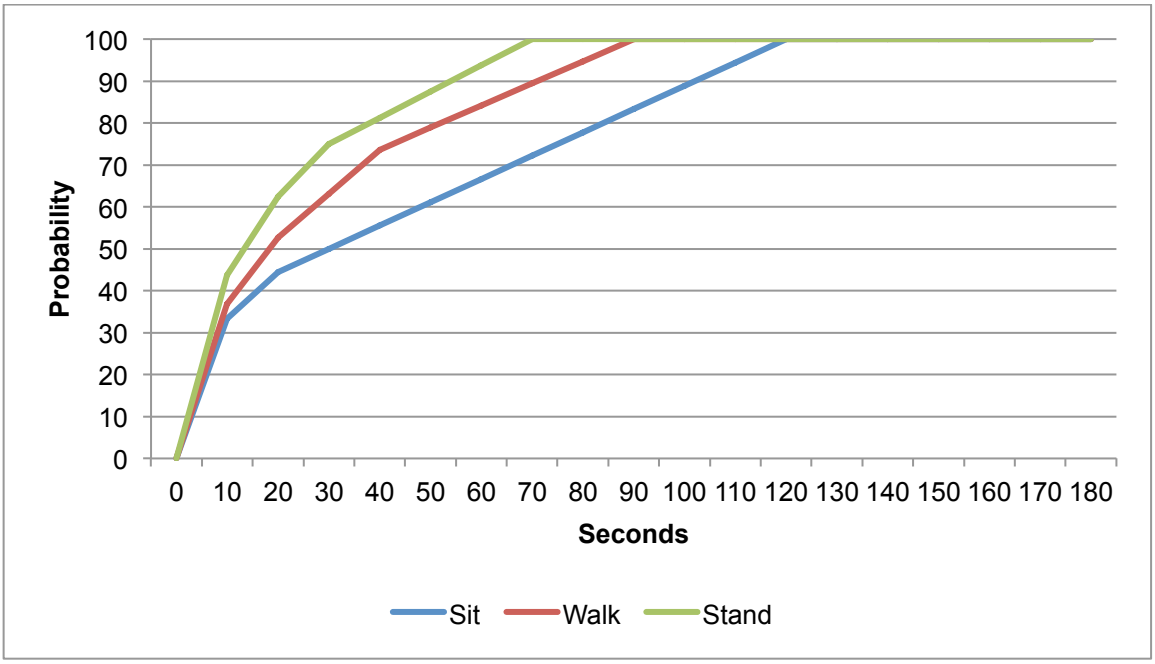

Figure 41: Survival analysis plot for the rate of recovery values for RMS of the RRF

3.2.2 MDF

MDF values for return to pre-kneeling baseline values (Figure 42) for all muscles and all tasks at times ranging from 0 to 3 minutes. The task that, on average, showed the shortest time to return to pre-kneeling baseline values was sitting, with a minimum value of 0.63(0.62) minutes for the RGL and a maximum of 1.29(0.99) minutes for the RTA muscle, with the rest of the muscles falling between these values.

The RGL and RRA muscles MDF recovered to pre-kneeling baseline values fastest when sitting, with average times of 0.63(0.62) and 1.11(0.47) minutes. RTA, RES, RVM, and RRF muscles MDF returned to their baseline values fastest while walking, with average times to return to pre-kneeling baseline values of 0.69(0.60), 0.94(0.80), 0.80(0.77), and 0.94(0.77) minutes respectively.

The standing posture showed the fastest return to pre-kneeling baseline values for the RVL, RGM, LRA, and LES muscles. The average times to return to their pre-kneeling baseline values were 0.88(0.77) minutes for the RVL, 0.82(0.81) for the RGM, 1.18(0.88) for the LRA, and 0.76(0.56) minutes for the LES.

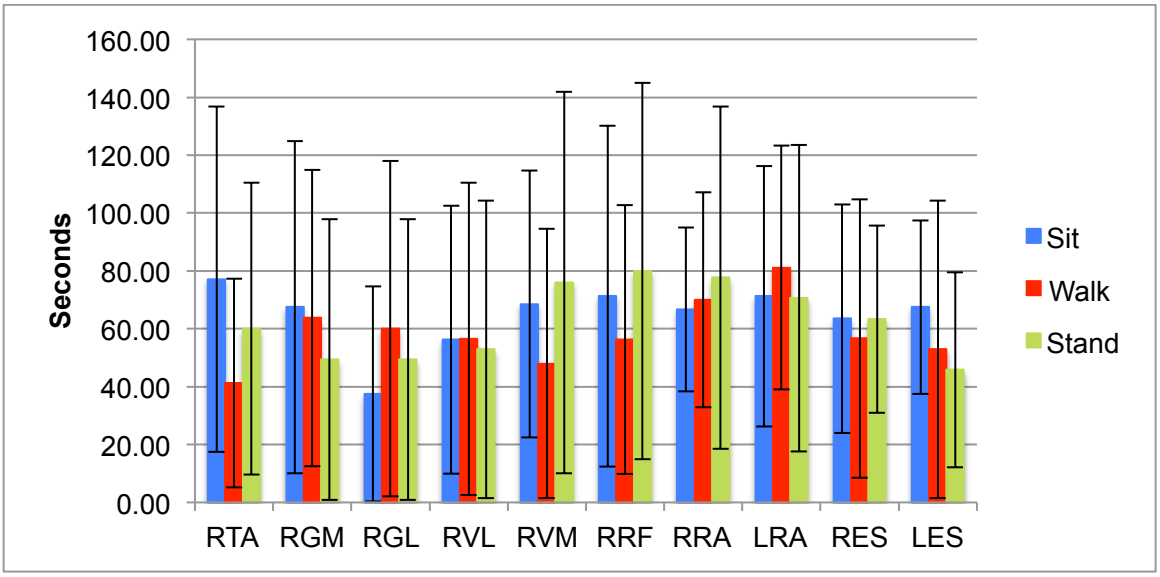

Figure 42: Average time to return to pre-kneeling baseline values for MDF

Each of the muscles showed a different slope in rate of recovery for each of the post-kneeling tasks.

3.2.2.1 RVL Muscle

3.2.2.1.1 Rate of Recovery

For the RVL muscle (Figure 43) the sitting and walking condition had similar slopes for MDF recovery with a sharp decrease within the first 10 seconds, followed by a leveling out. Conversely, the standing task had a gradual decrease in recovery rate but with initial values lower than those for the other two post-kneeling tasks. ANOVA showed statistically significant difference between the post-kneeling tasks (*p-value*=0.0001). Tukey test indicated that standing post-kneeling task is different from sitting and walking (*p-value*<0.05)..

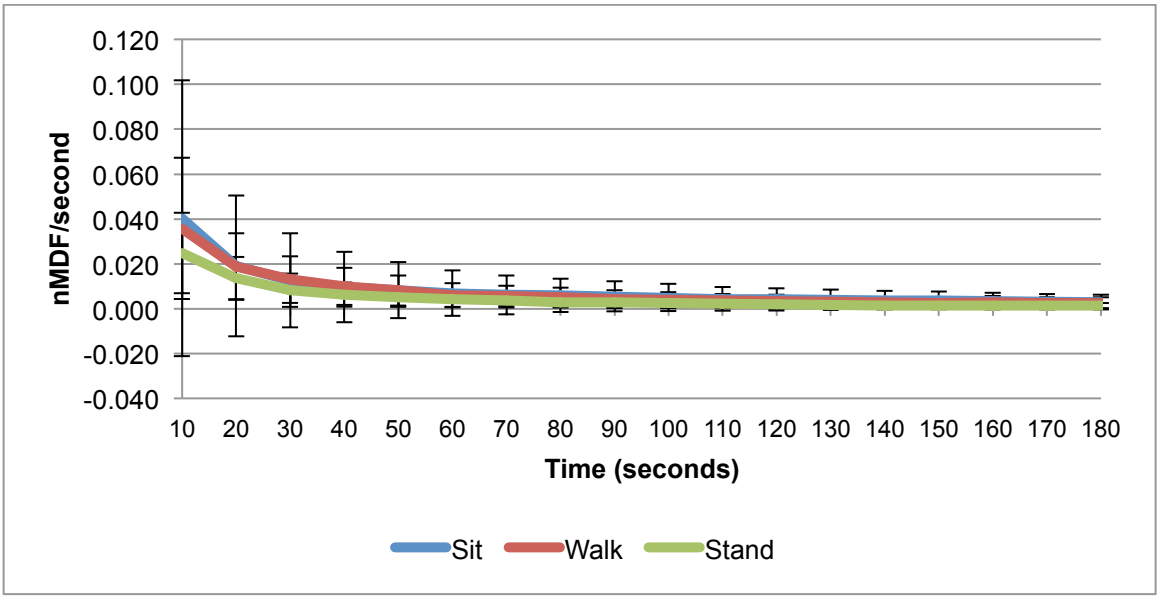

Figure 43: MDF rate of recovery for RVL muscle

3.2.2.1.2 Survival Analysis

The survival analysis plot showed that standing task reached 100% by 50 seconds, sitting by 90 seconds, and walking by 80 seconds. However the difference between the tasks was found to not be statistically significant.

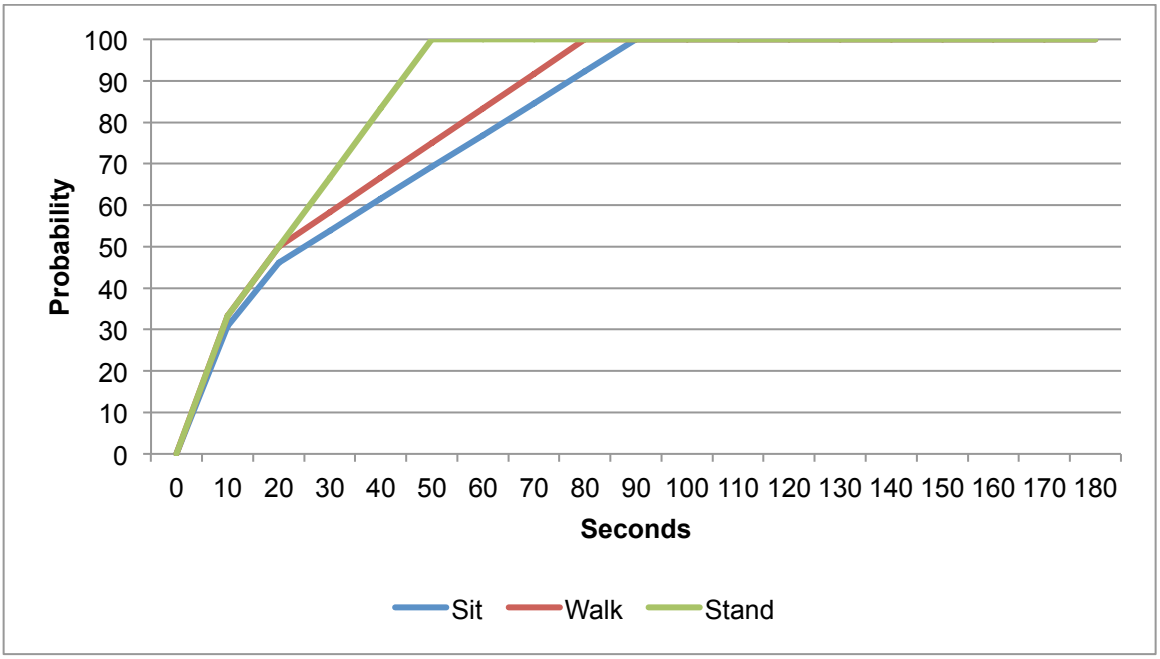

Figure 44: Survival probability plot for the rate of recovery values for MDF of the RVL muscle

3.2.2.2 RTA Muscle

3.2.2.2.1 Rate of Recovery

The RTA muscle (Figure 45) had a steep decline in recovery rate during the first 10 seconds for all three tasks. The sitting and standing tasks had almost exactly the same trend during the whole post-kneeling section, reaching the pre-kneeling baseline at 110 seconds. Tukey test showed that there is a statistically significant difference between walking task and sitting and standing (*p-value*<0.0001).

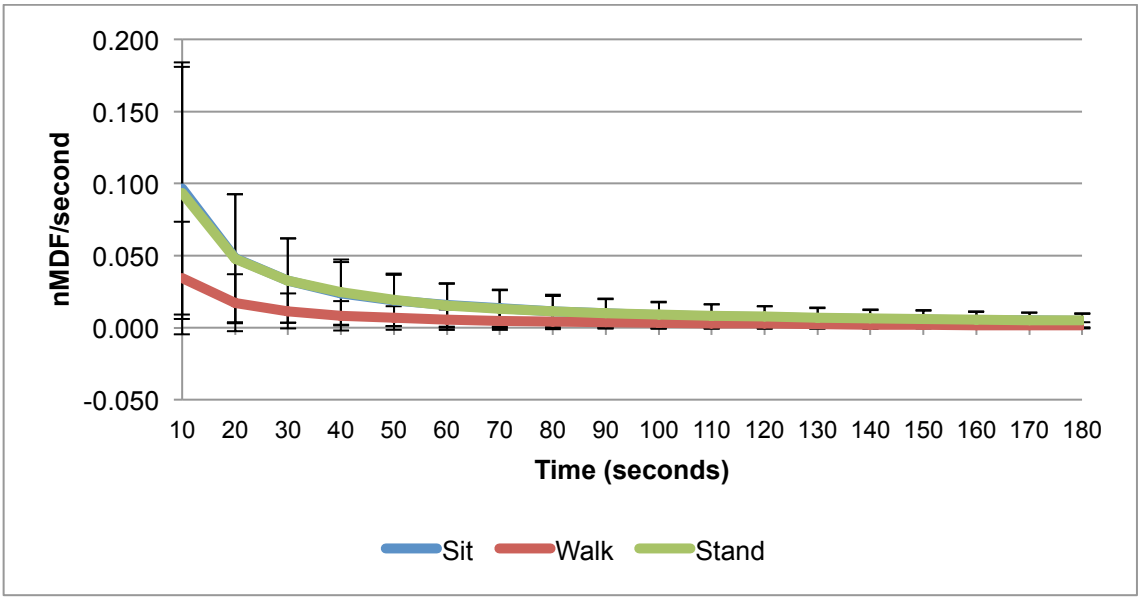

Figure 45: MDF rate of recovery for the RTA muscle

3.2.2.2.2 Survival Analysis

Survival analysis for the RTA muscle MDF values indicate that sitting task took the longest to reach 100% needing 3 minutes, while for walking and standing on 50-60 seconds were required. Differences between post-kneeling tasks were not statistically significant.

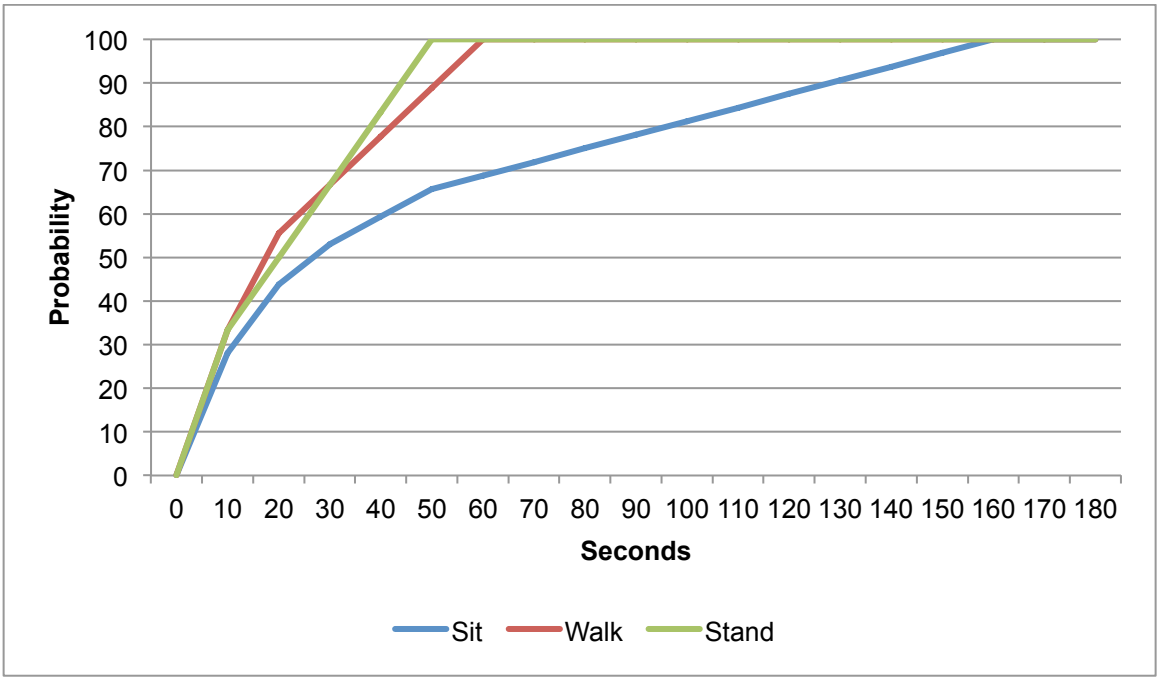

Figure 46: Survival probability plot for the rate of recovery values for MDF of the RTA muscle

3.2.2.3 RGM Muscle

3.2.2.3.1 Rate of Recovery

The RGM muscle MDF (Figure 47) rate of recovery did not exhibit a steep slope for any of the three post-kneeling tasks. However the walking task showed the fastest recovery rate having an initial value of 0.088 normalized MDF per minute and the sitting task the slowest with an initial value of 0.017 normalized MDF per minute. The sitting task also had an initial value that was approximately ¼ of the initial value for the walking task. With a p-value of 0.0001 sitting task was seen to be statistically significant different from the other two post-kneeling tasks.

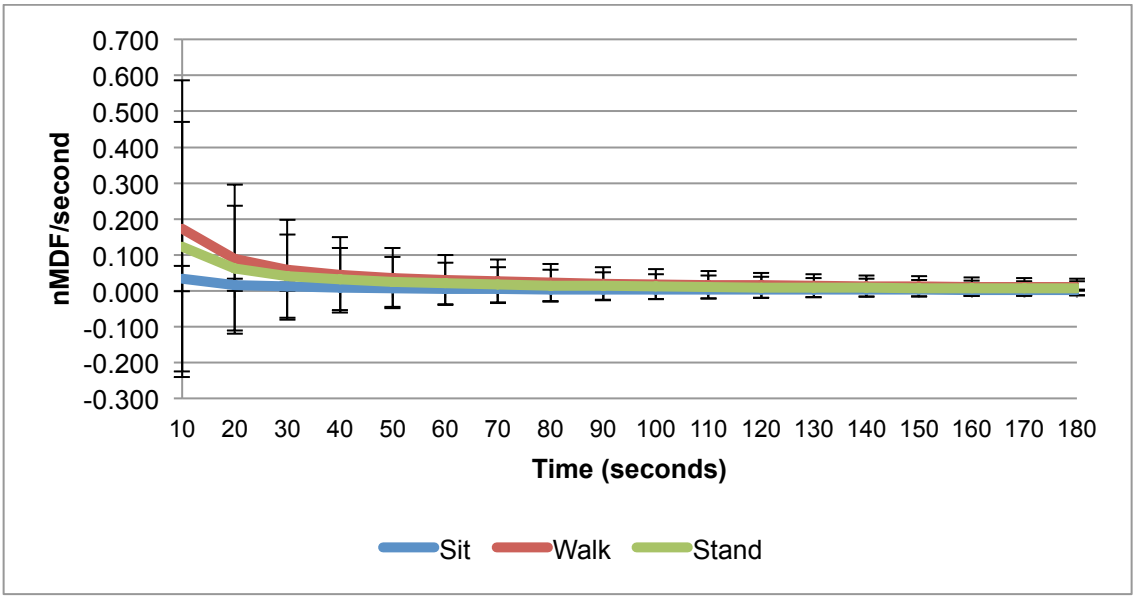

Figure 47: MDF rate of recovery for the RGM muscle

3.2.2.3.2 Survival Analysis

The sitting task showed to be the fastest one to reach 100% requiring only 60 seconds, while for standing and walking the full 3 minutes were required to reach 100%. Differences between the post-kneeling tasks were not statistically significant.

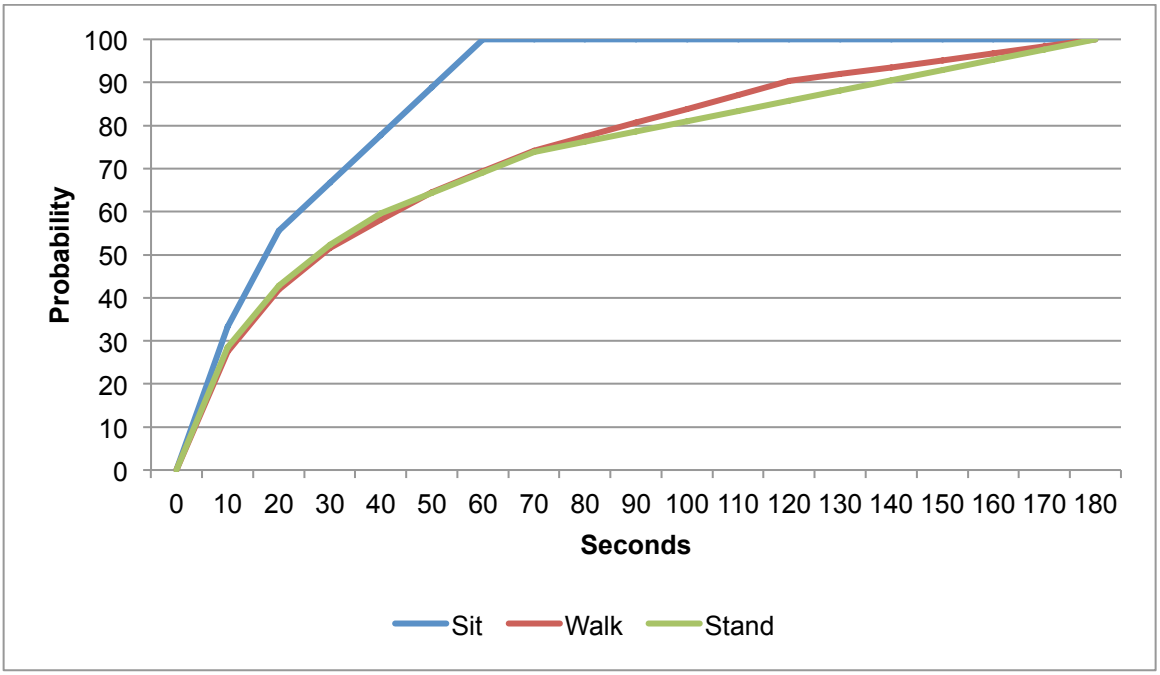

Figure 48: Survival probability plot for the rate of recovery values for MDF of the RGM muscle

3.2.2.4 RGL Muscle

3.2.2.4.1 Rate of Recovery

The RGL muscle (Figure 49) did not exhibit a large difference between the rates of MDF to recover for any of the three post-kneeling tasks. All the task recovery rates had a similar slope, with the sitting task showing an initial value of 0.025 normalized MDF per second, which was the highest of the three tasks.

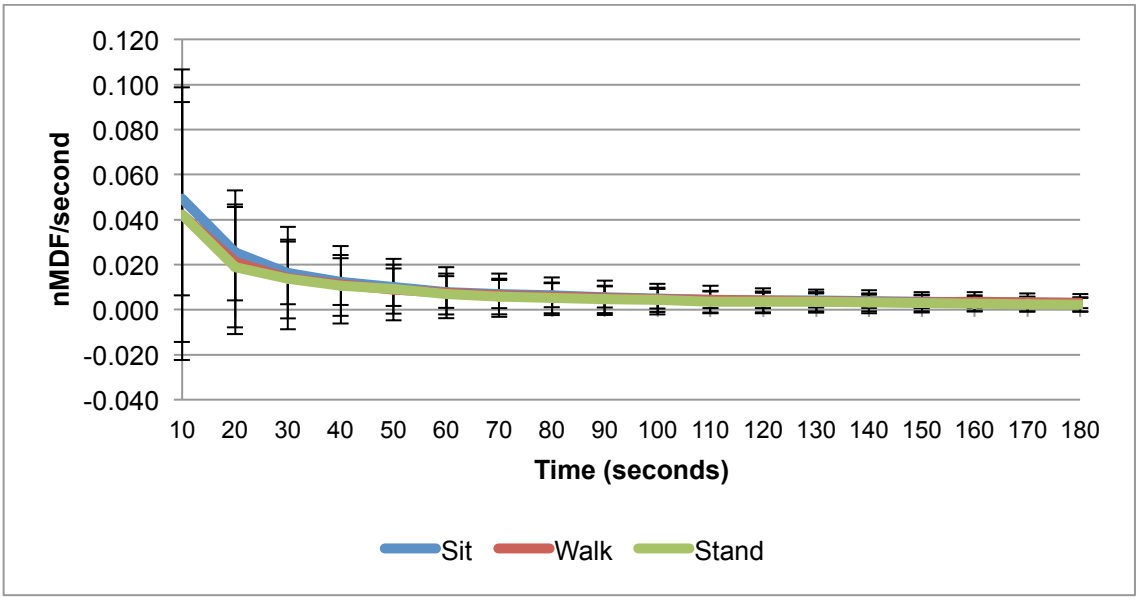

Figure 49: MDF rate of recovery for the RGL muscle

3.2.2.4.2 Survival Analysis

For the RGL muscle all the post-kneeling tasks showed a very similar trend, with all of them reaching 100% between 80 and 90 seconds. Difference was not statistically significant.

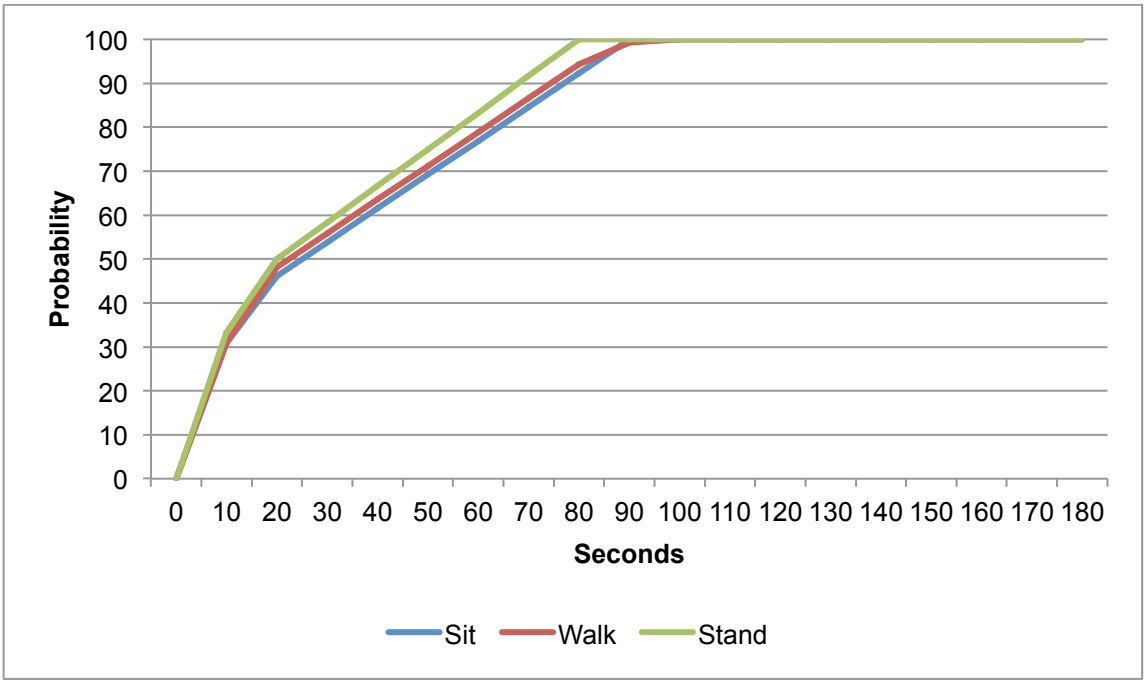

Figure 50: Survival analysis plot for the rate of recovery values of the MDF for the RGL muscle

3.2.2.5 RRA and LRA Muscles

3.2.2.5.1 Rate of Recovery

The abdominal muscles (RRA and LRA) (Figures 51 and 52) had the slowest rate of MDF recovery while standing at 0.009 normalized MDF per second for the RRA and 0.008 for the LRA. For both muscles, walking had the fastest recovery rate. RRA muscle showed a statistically significant difference (*p-value*=0.001) with standing being different from the other two post-kneeling tasks, while the LRA muscle did not have significant difference (*p-value*=0.414).

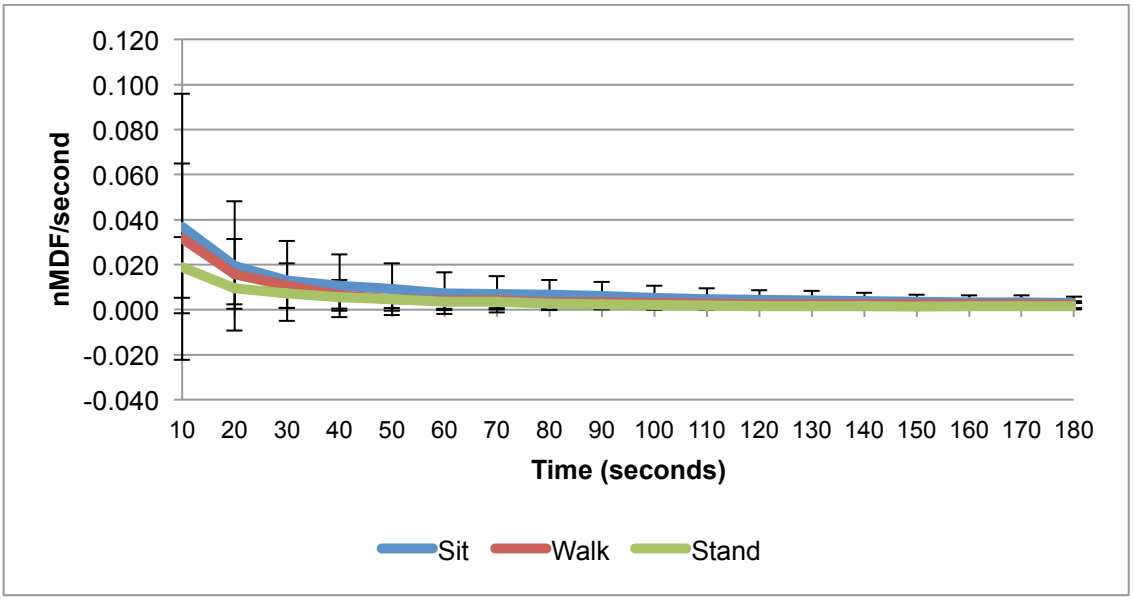

Figure 51: MDF rate of recovery for the RRA muscle

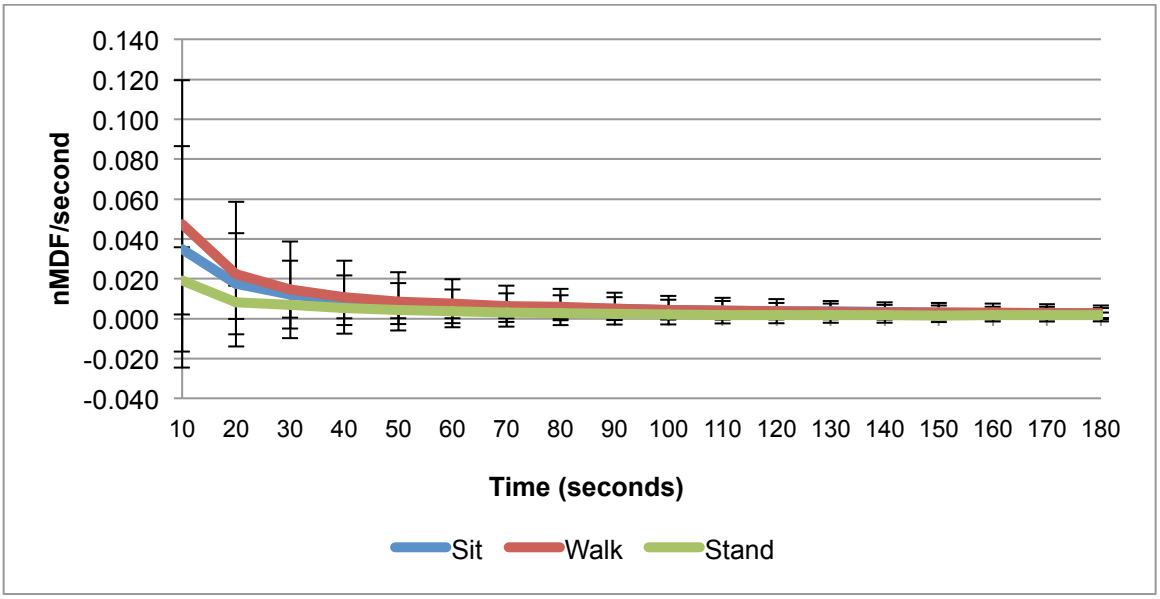

Figure 52: MDF rate of recovery for the LRA muscle

3.2.2.5.2 Survival Analysis

For the RRA muscle MDF the difference between sitting and walking tasks was statistically significant with a p-value of 0.0323. For this muscle, walking and standing

reached 100% within 40 seconds. As for the LRA muscle, sitting task also required more time to reach 100% (180 seconds). However for this muscle there were no statistically different differences between tasks.

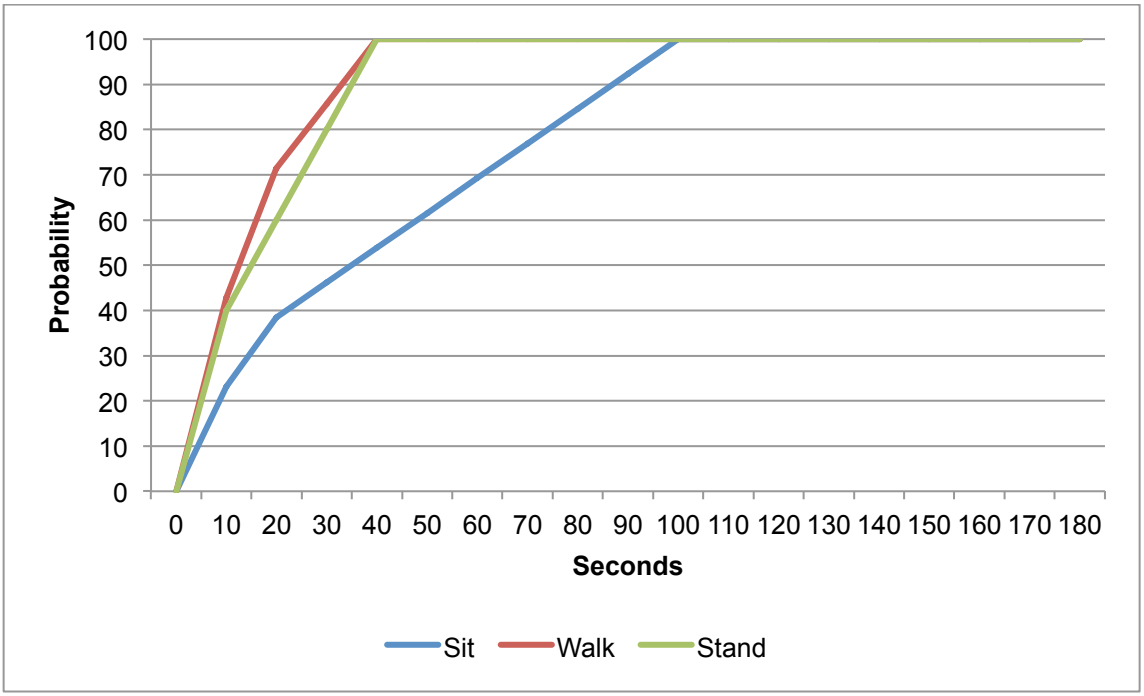

Figure 53: Survival analysis plot for the rate of recovery values of the MDF for the RRA muscle

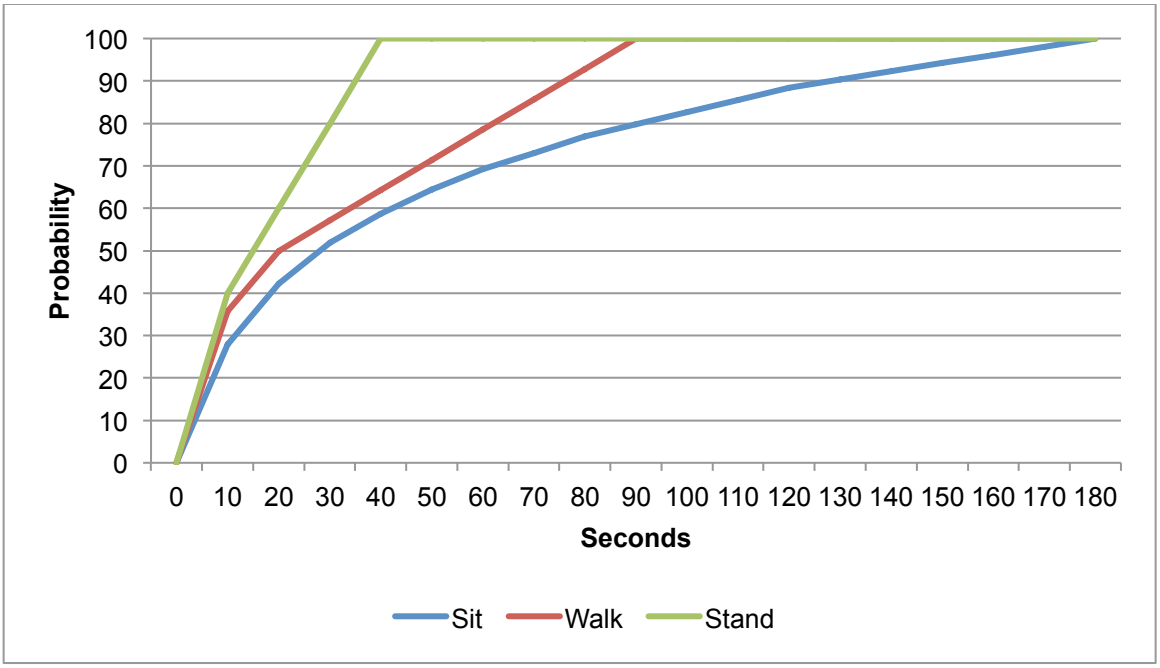

Figure 54: Survival analysis plot for the rate of recovery values for the MDF of the LRA muscle

3.2.2.6 RES and LES Muscles

3.2.2.6.1 Rate of Recovery

For both spinal muscles (RES and LES) (Figures 55 and 56) the sitting task had the highest initial recovery rate of 0.032 normalized MDF per second for the RES and 0.028 for the LES, with the steepest decrease during the first 10 seconds of the post-kneeling section. The walking and standing tasks had similar values and followed the same trend. ANOVA showed that the differences between post-kneeling tasks were found to be statistically significant for both muscles. Sitting was found to be different from sitting and standing for the RES muscle (*p-value*=0.001) and the LES muscle (*p-value*=0.0001).

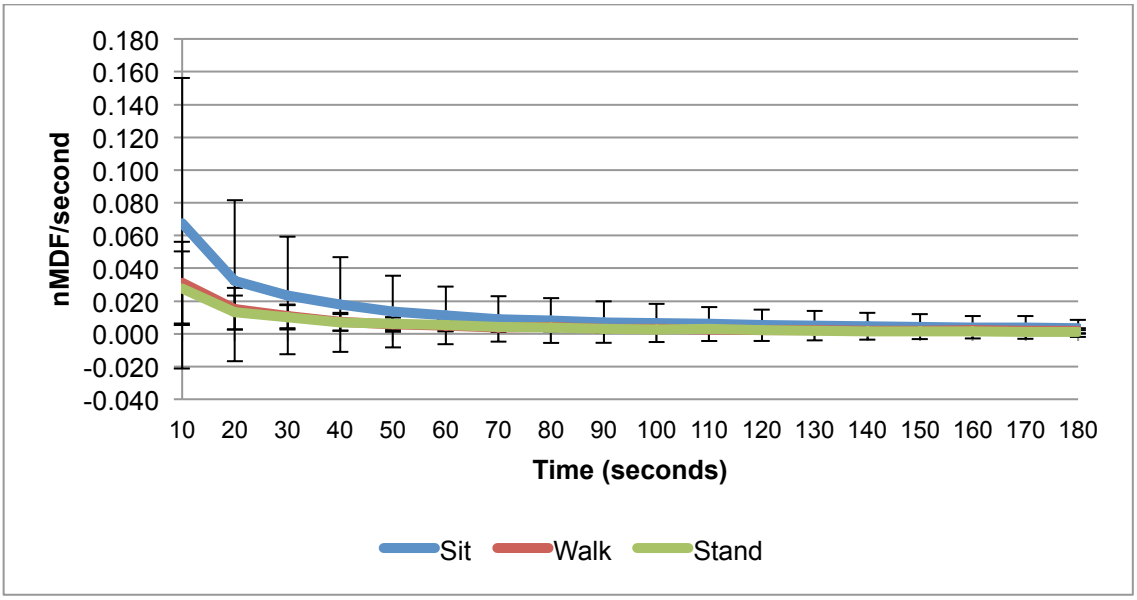

Figure 55: MDF rate of recovery for RES muscle

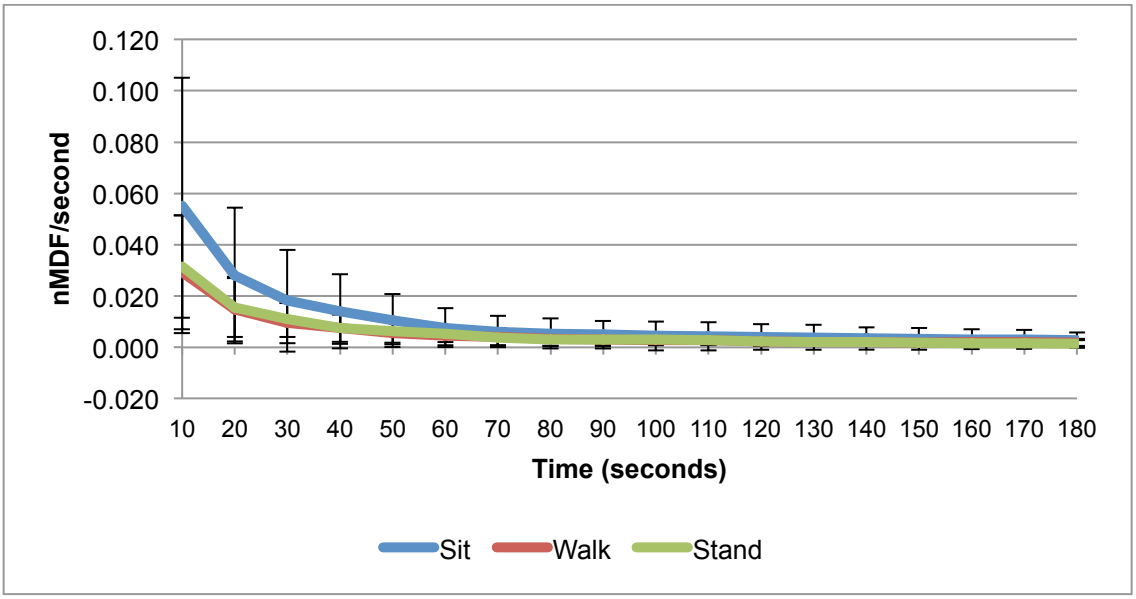

Figure 56: MDF rate of recovery for LES muscle

3.2.2.6.2 Survival Analysis

For both muscles survival analysis indicated that sitting task requires more time to reach 100%, similar to the abdominal muscles. For both muscles no more than 110 seconds were needed to reach 100%. The differences were not statistically significant between the post-kneeling tasks.

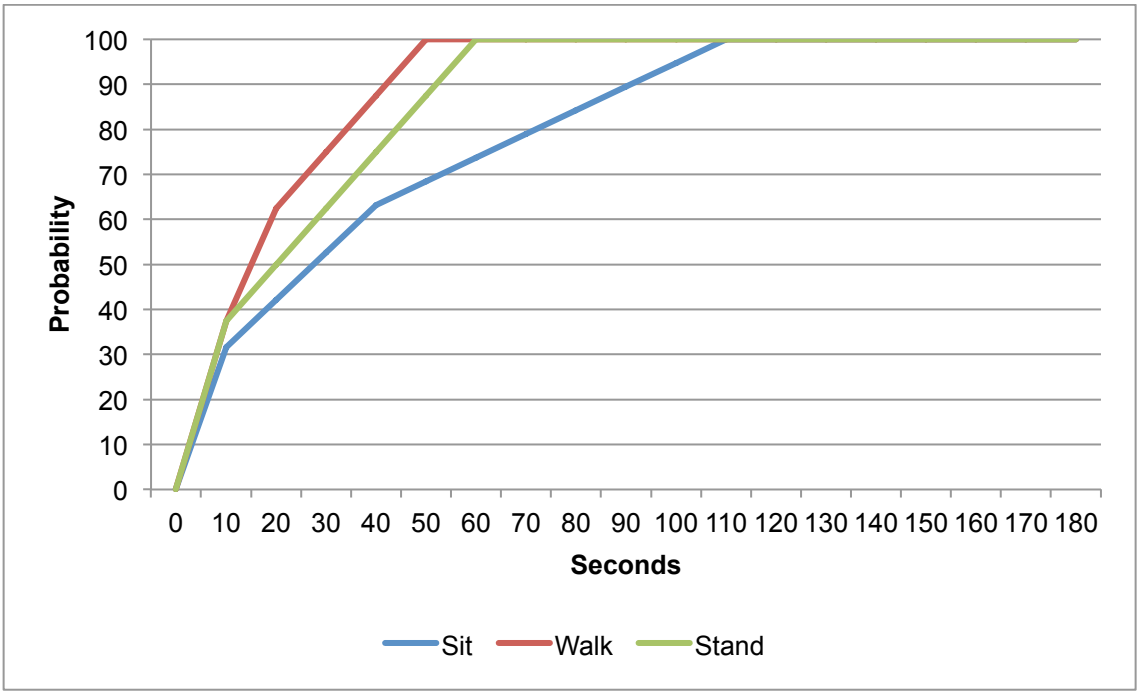

Figure 57: Survival analysis plot for the rate of recovery values for the MDF of the RES muscle

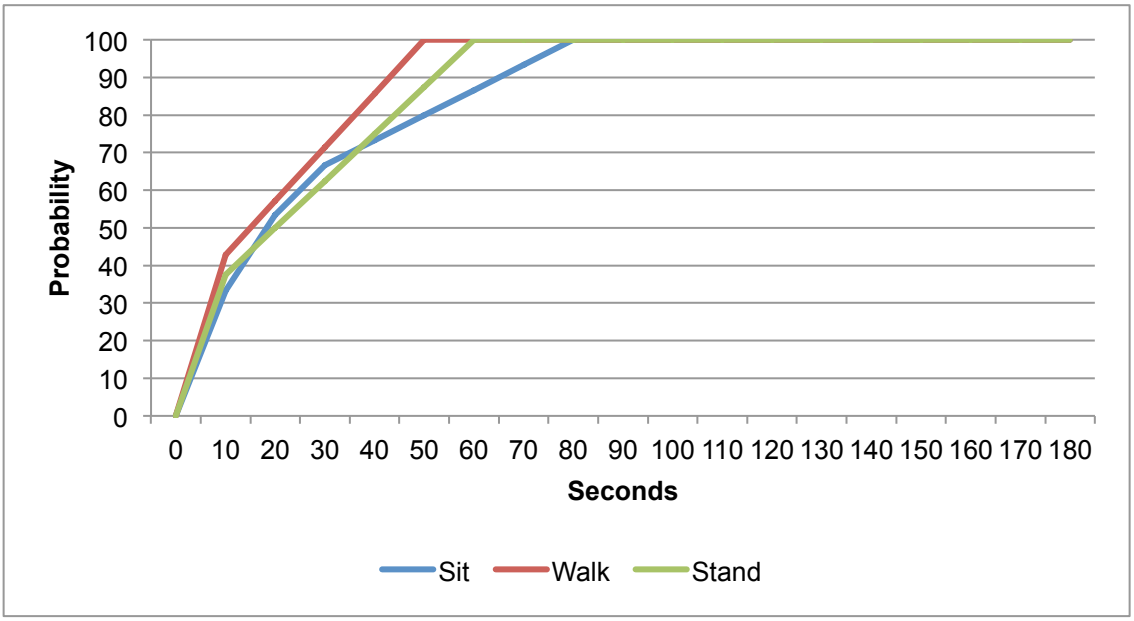

Figure 58: Survival analysis plot for the rate of recovery values for the MDF of the LES muscle

3.2.2.7 RVM Muscle

3.2.2.7.1 Rate of Recovery

The RVM muscle MDF (Figure 59) had the fastest time to return to pre-kneeling baseline values for the sitting (1.14 minutes) and standing (1.27 minutes) tasks. However, the walking task had the fastest rate of MDF recovery (0.070 normalized MDF per second), with a steeper slope during the first 40 seconds of the post-kneeling section. Walking post-kneeling task was found to be significantly different from sitting and standing (*p-value*=0.0001).

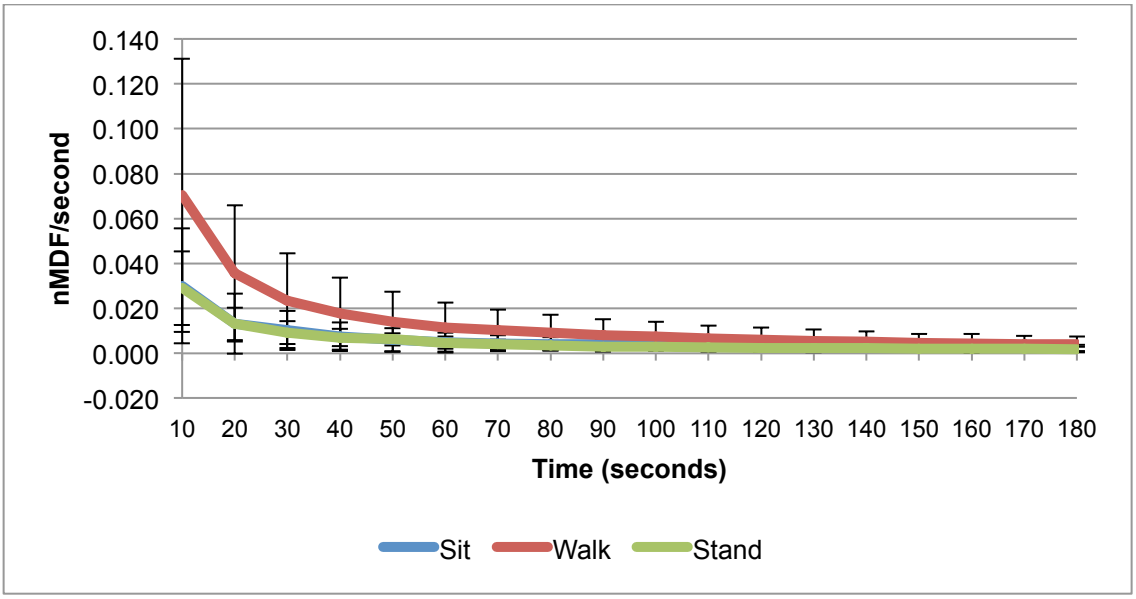

Figure 59: MDF rate of recovery RVM muscle

3.2.2.7.2 Survival Analysis

Survival analysis showed that sitting and standing reached 100% by 50 seconds, while walking reached it at 130 seconds. The differences between the post-kneeling tasks were not statistically significant.

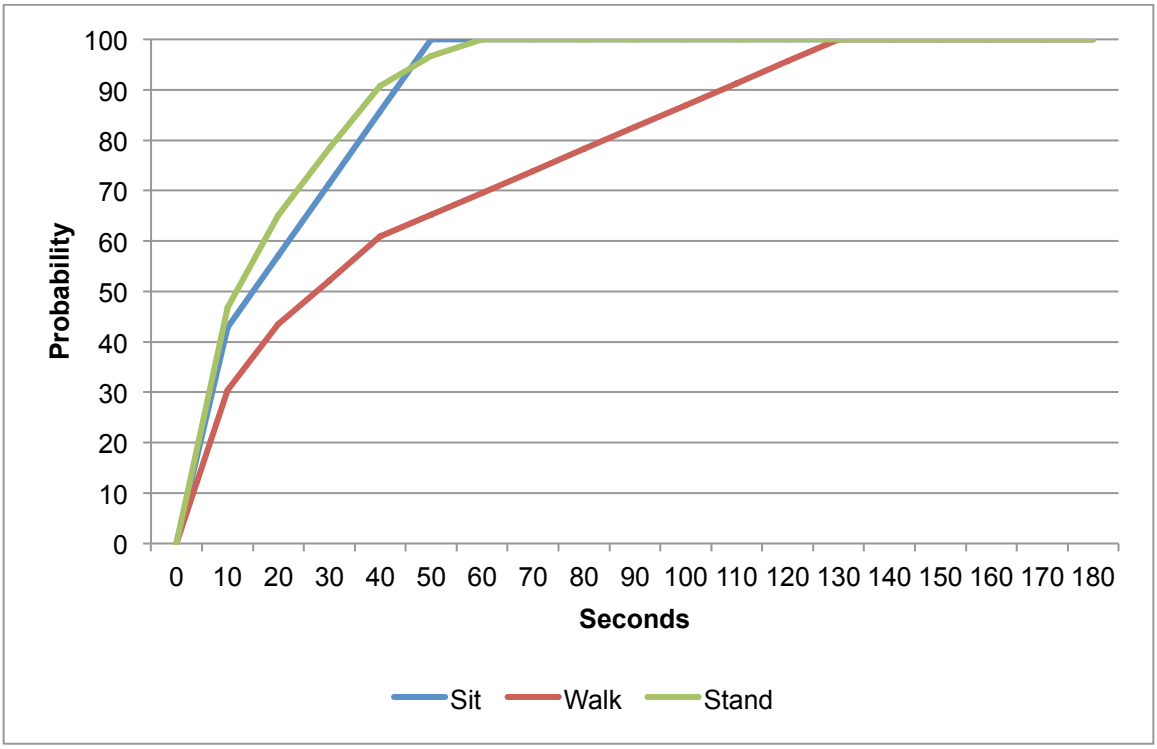

Figure 60: Survival analysis plot for the rate of recovery values for the MDF of the RVM muscle

3.2.2.8 RRF Muscle

3.2.2.8.1 Rate of Recovery

The RRF muscle MDF (Figure 61) showed a large variation among recovery rate values during the first 30 seconds of the post-kneeling section, with values ranging from 0 to 0.4 normalized MDF per second. The standing task had a lower initial value (0.024 normalized MDF per second), making it the task in which values returned to pre-kneeling baseline conditions fastest, while the sitting and walking tasks had the fastest rates of recovery. The differences between the post-kneeling tasks showed no statistical significance with a *p-value* of 0.091.

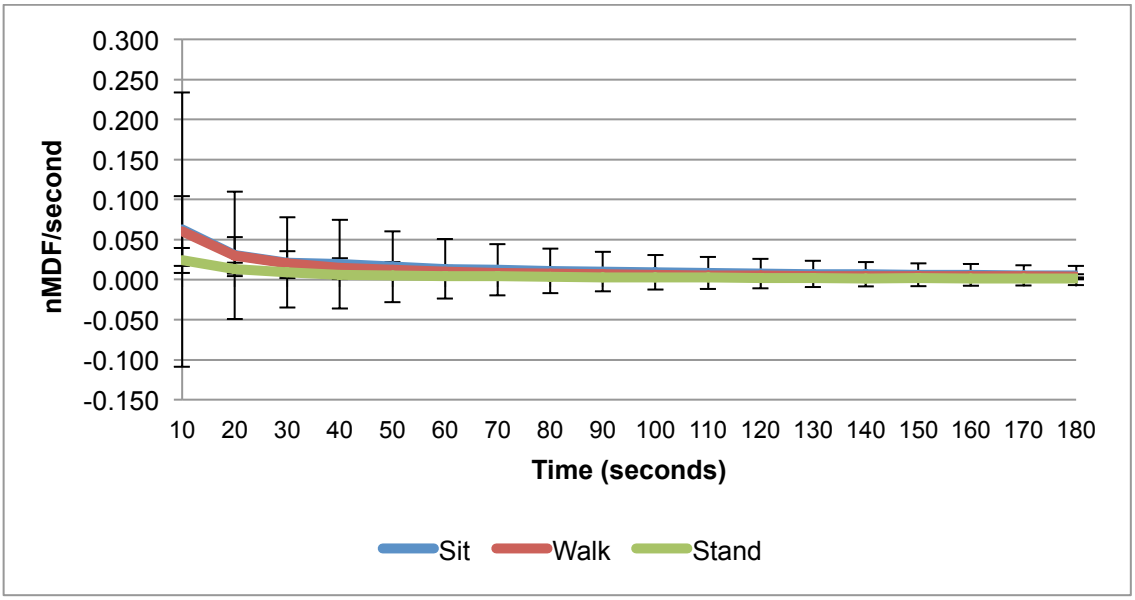

Figure 61: MDF rate of recovery RRF muscle

3.2.2.8.2 Survival Analysis

For the RRF muscle standing task showed the fastest trend. The difference between sitting and standing task appeared to be statistically significant with a *p-value* of 0.0448. The differences between the other post-kneeling tasks were not statistically significant.

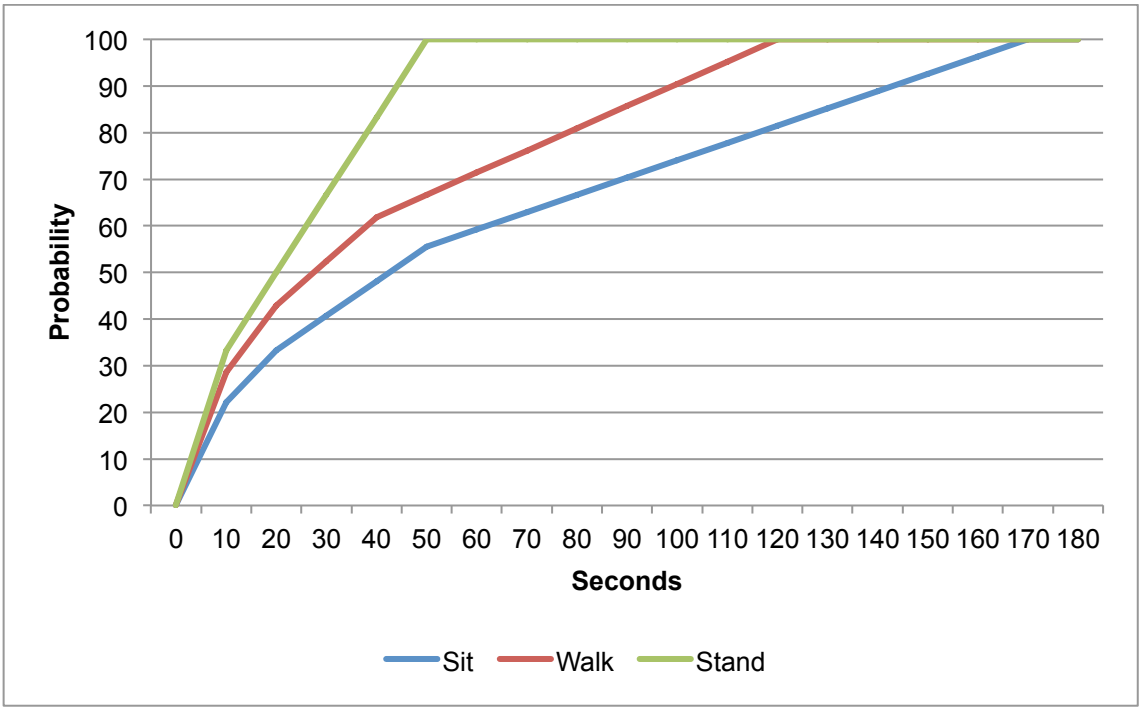

Figure 62: Survival analysis plot for the rate of reovery values for the MDF of the RRF muscle

3.2.3 Overall EMG Summary

Tables 4 and 5 show the time it takes for the muscles to reach their pre-kneeling baseline values with probabilities of 50% and 95%. By comparing all the muscles it is clear that for RMS the walking task is the most efficient overall, requiring a maximum of 200 seconds to return to pre-kneeling baseline values with a probability of 95% (Table 2). The maximum time for the sitting and standing tasks is 210 seconds.

Table 4: RMS time (seconds) to return to pre-kneeling baseline values with a probability of 50% and 95%

Muscle	Post-kneeling task (Seconds)					
	Sit		Walk		Stand	
	50%	95%	50%	95%	50%	95%
RTA	60	200	20	200	40	200
RGM	40	160	10	200	50	180
RGL	70	200	70	210	30	180
RVL	20	210	30	120	40	160
RVM	60	200	60	200	70	200
RRF	40	110	50	120	30	200
RRA	20	100	30	140	20	200
LRA	40	120	40	140	20	170
RES	40	180	30	200	90	200
LES	40	90	60	210	110	200

For MDF, the same analysis was performed. For each post-kneeling task the muscle with the longest time to recovery will be the one limiting the total time to return to pre-kneeling baseline values. As for RMS, walking is the task that returns to pre-kneeling baseline values the fastest overall, with a maximum of 200 seconds (Table 5). The other two tasks, sitting and standing, have times of 220 and 210 seconds respectively.

Table 5: MDF time (seconds) to return to pre-kneeling baseline values with a probability of 50% and 95%

Muscle	Post-kneeling task (seconds)					
	Sit		Walk		Stand	
	50%	95%	50%	95%	50%	95%
RTA	80	220	20	200	40	100
RGM	40	210	30	210	40	160
RGL	20	220	30	200	30	130
RVL	30	210	20	200	20	200
RVM	70	220	20	220	50	200
RRF	20	200	20	200	40	160
RRA	40	90	40	110	50	200
LRA	50	210	60	200	30	140
RES	40	200	20	150	30	120
LES	50	200	30	200	20	70

For these times to return to pre-kneeling baseline values (50% and 95% probability) an ANOVA was run for RMS and MDF separately as two responses. None of the main factors i.e. muscle type and post-kneeling task were significant for the RMS. However post-kneeling task was significant for the MDF, and specifically, standing resulted in significantly different recovery times that the two other post-kneeling tasks with a p-value of 0.019. An interaction plot was made in order to determine if the main factors interacted RMS (Figures 63 and 64) and MDF. , The expectation was for the lines of the muscles and the tasks to be parallel. However, all the interaction plots (for RMS and MDF) indicate significant interactions between muscle type and task, thus no particular post-kneeling task appears to result in fast recovery across all muscle types.

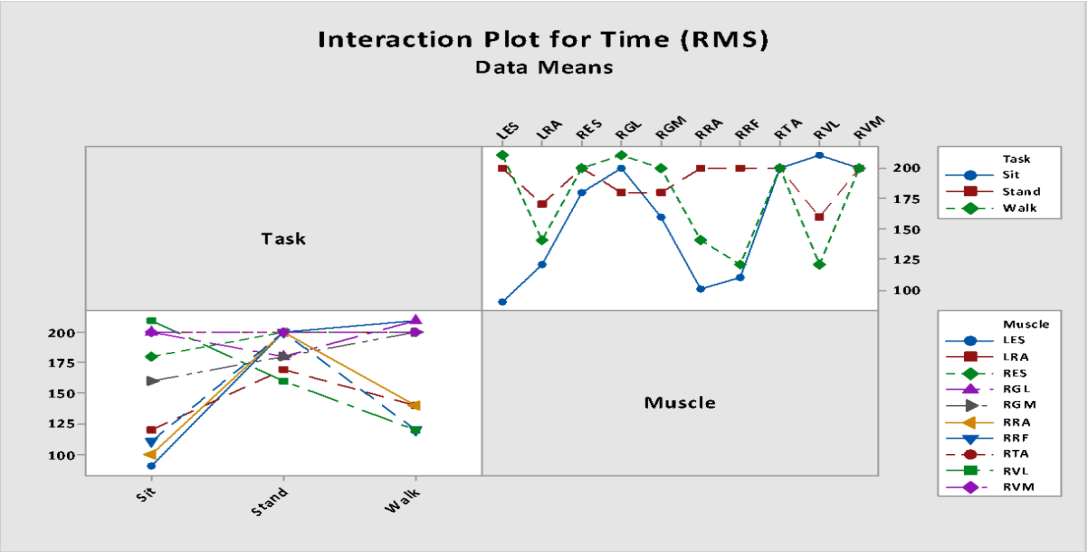

Figure 63: Interaction plot for time for RMS recovery (95% probability)

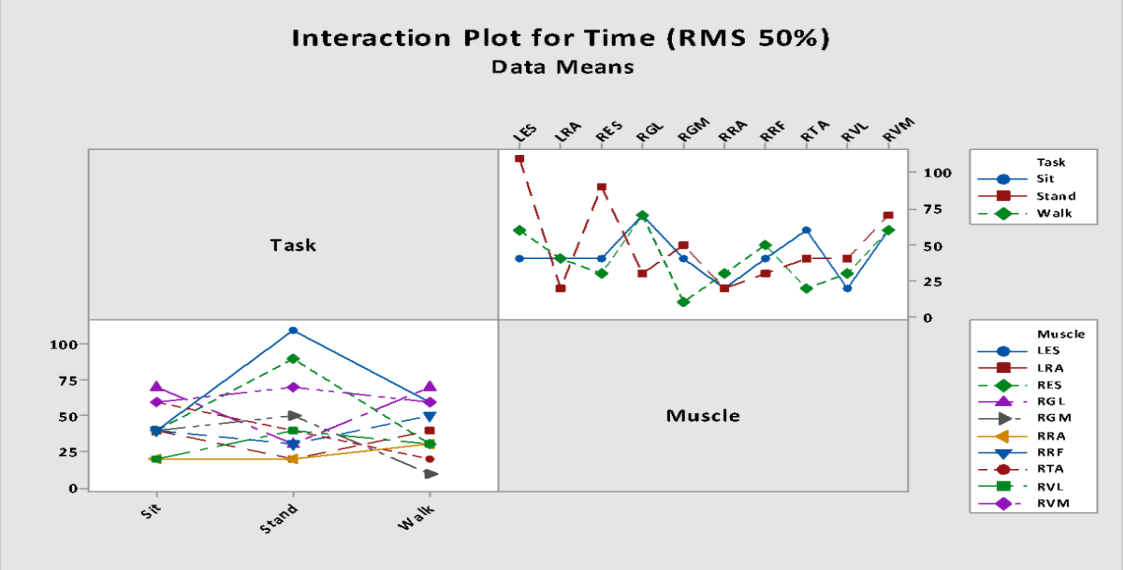

Figure 64: Interaction plot for time for RMS recovery (50% probability)

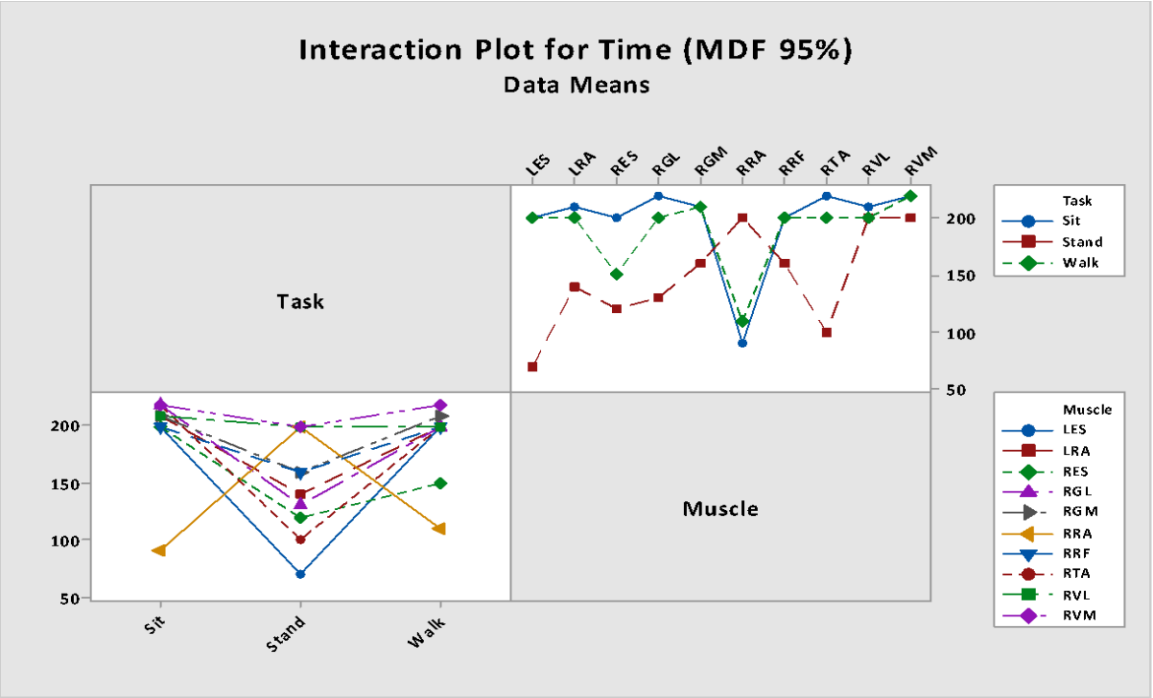

Figure 65: Interaction plot for time for MDF recovery (95% probability)

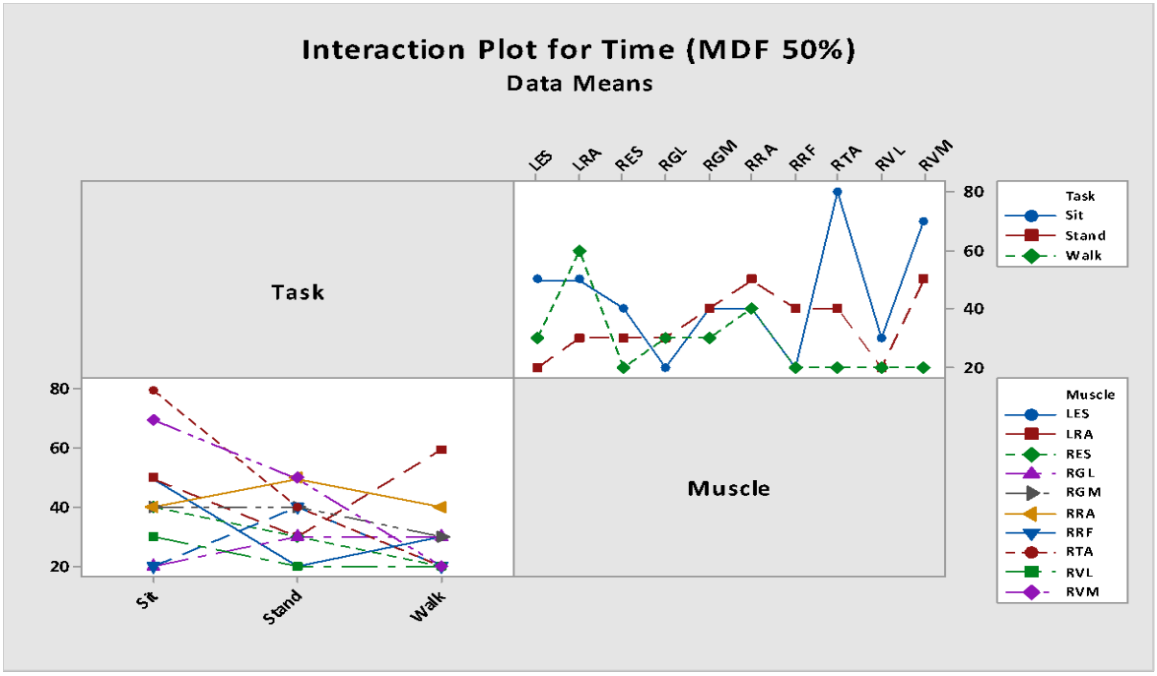

Figure 66: Interaction plot for time for MDF recovery (50% probability)

3.3 Range of Motion

After the post-kneeling task was completed, minimal or no changes were seen in ROM for the knee and ankle. The average percent changes in ROM at the knee and ankle ranged between -2% to 2% for all post-kneeling conditions.

3.3.1 Knee

For the three post-kneeling tasks the average change in ROM ranged from 0% to 2%. The task that showed the greatest change was walking, with an average increase of 2% and a standard deviation of 8% (Figure 67). However, 6 out of the 19 subjects showed a decrease in ROM after the walking task. A paired t-test was conducted to identify if the differences between pre-kneeling and after performing the post-kneeling task could be statistically significant. Results show that the difference is not significant with a *p-value* of 0.30.

The sitting post-kneeling task had an average change of 0(5)% with a range of -4 to 8 degrees (Figure 67), 8 subjects had a decrease in ROM, one showed no change and the rest of the subjects increased their ROM.

The last post-kneeling task, standing, had an average change of 1(5)% (Figure 67) and a range of -7 to 8 degrees, 7 subjects showed a decrease in ROM, while 2 showed no change.

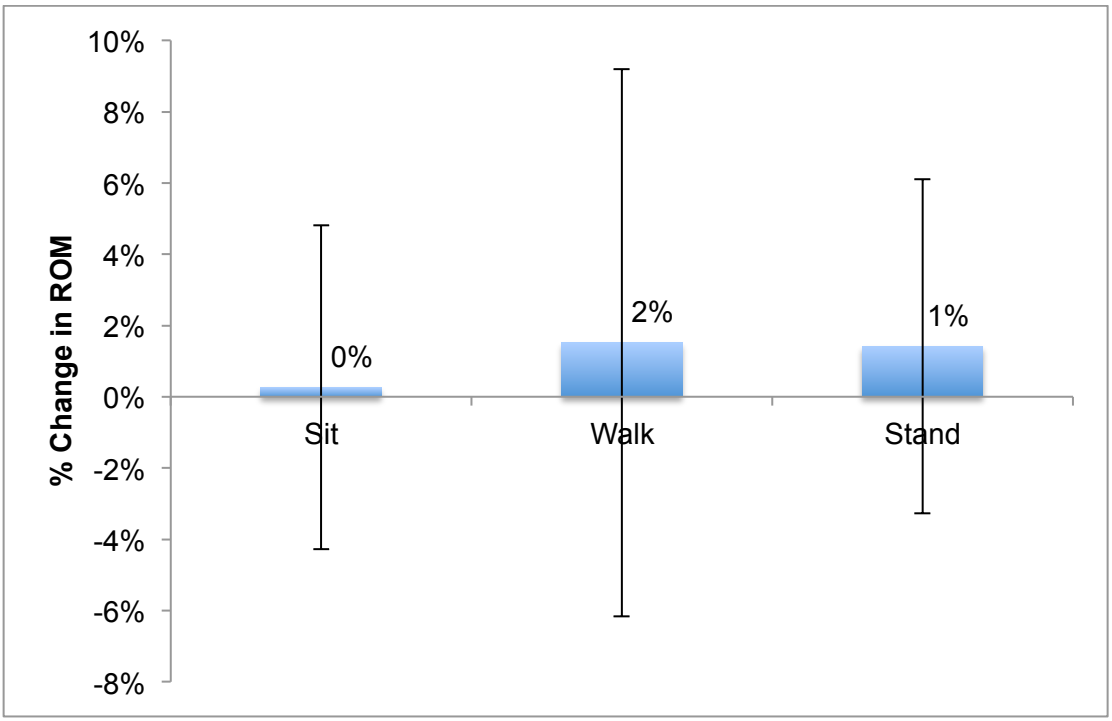

Figure 67: Percent change from pre-kneeling to end of post-kneeling task in ROM for the knee joint

3.3.2 Ankle

Two out of three post-kneeling tasks, walking and standing, had a 0% average change in ROM. The sitting task showed an average decrease of 2% (Figure 68).

The sitting task had the greatest variability among the post-kneeling tasks, with an average of -2% and a standard deviation of 6%. Absolute values for this task ranged between -13 degrees to 9 degrees.

The post-kneeling task of walking had a 0% change with a standard deviation of 5%, and a range of absolute values from -7 to 4 degrees of the ROM. The standing task showed the lowest variability with absolute values ranging from -3 to 4 degrees and a 0% average change in ROM with a standard deviation of 3%. A paired t-test was run to

identify if statistical significance was present in the values of pre-kneeling and after finishing the return to pre-kneeling baseline conditions. The test shows that the difference between these values is not significant with a *p-value* of 0.180.

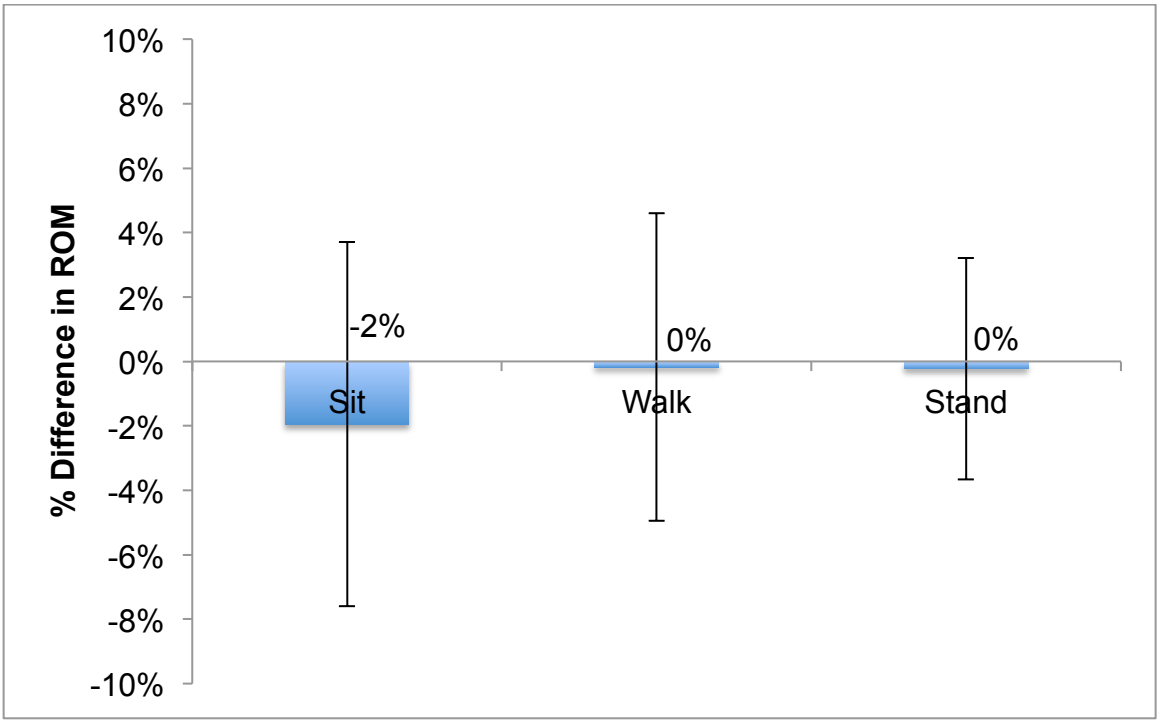

Figure 68: Percent change from pre-kneeling to end of post-kneeling task in ROM for the knee joint

4. Discussion

The overall goal of this study was to compare different post-kneeling tasks and identify which task is the most effective at promoting recovery. Changes in the biomarkers of muscle activity, muscle oxygenation, and ROM were investigated. The results indicate that the sitting post-kneeling task is the most effective at promoting recovery when workers were previously kneeling, while the standing task was the least effective.

From the analysis of all the biomarkers, the time to return to pre-kneeling baseline value was controlled by muscle oxygenation, which had 4 minutes as the fastest time to return to baseline values, while for muscle activity the longest recovery time is 3 minutes. That is, it requires a longer time for muscles to “regain” their pre-kneeling oxygenation than it takes to recovery muscle activity.

The results of this study provide evidence that workers should walk or sit for at least 4 minutes before returning to their normal activities. Results for each biomarker are discussed in detail in the following sections.

4.1 Muscle Oxygenation

The %rSO_2 values provide information on how much oxygen is present in the blood of the lower leg while kneeling and during the post-kneeling task. It was hypothesized that the time for rSO_2 levels to return to pre-kneeling baseline conditions would be task dependent. This hypothesis was upheld, as the time to return to baseline values of rSO_2 was task dependent and the differences between tasks were statistically

significant. This study suggests that a worker should walk, without any external loads, for at least 4 minutes in order for muscle oxygenation values to return to the values that they had before the kneeling trial. Longer recovery times were required for sitting and standing.

The walking task returned the TA muscle to its pre-kneeling baseline values fastest, while for the MG muscle the sitting task was the most efficient. It has been found that the MG muscle generates the horizontal propulsive forces when walking, constituting almost half of the metabolic cost during normal walking (Gottschall et al., 2003), and subsequently walking could generate a shorter time for the TA to return to pre-kneeling baseline values. Previous research has shown that the TA muscle and RA muscles are activated first in the most natural condition of the sit-to-stand position (Rodrigues-de-Paula et al., 1999), which could indicate that the MG muscle would recover faster while sitting, given that in this posture the foot is at a 90° angle, so the MG is relaxed, while the TA is engaged.

Research analyzing the differences in muscle oxygenation patterns with and without blood restrictions (Kawada, 2005) has shown that when there is a blood flow occlusion the oxygen is not able to reach the muscles and could cause muscle cell necrosis if the muscle is not released promptly (Harmon, 1948; Strock et al., 1969). In the case of kneeling, the action of flexing the knee joint and applying pressure to the lower leg works as a tourniquet restricting blood flow. However, since the subject did not have mobility completely restricted, the kneeling posture allowed them to sway and move their position slightly, causing the tourniquet to be released and generating an influx of blood to the lower leg even when they were still kneeling. Since these

movements were unrestricted, they could vary greatly between subjects, resulting in a large variation in rSO_2 recovery rate.

The survival analysis test showed that there is a 95% probability of returning to pre-kneeling baseline values in 9 minutes for the TA and 7 minutes for the MG for the walking task. On the other hand, for the sitting and standing tasks the 95% probability recovery times are 9 and 11 minutes for the TA, and 8 and 9 minutes for the MG respectively. The standing task may require the longest recovery because the majority of the muscles being investigated are working in order to keep the body stabilized in the standing posture (Hodges et al., 1997). Muscles have to work harder to maintain balance because kneeling causes a decrease in muscle strength (Hernandez et al., 2010) and this muscle strength decrease is generated, at least in part, by the decrease in muscle oxygenation (Yamayi et al., 2004).

With these results it is clear that a worker should either sit or walk for 9 minutes, and stand for at least 11 minutes after a prolonged kneeling task in order to fully recover.

, There is however, no standard recommendation on how much time a worker should rest after kneeling for any industry. OSHA only mentions that a worker should take rest periods every two hours. Additionally, it is only indicated that short breaks should be taken in order to switch the muscle groups being worked (OSHA, 2005). NIOSH has also looked at the kneeling task and they recommend avoiding prolonged kneeling in order to minimize muscle and joint problems (NIOSH, 2007). Therefore, the recommendation to industry from this research is that a worker should either sit or walk for 9 minutes, or to stand for 11 minutes, in order to allow the lower leg muscles to return to their pre-kneeling rSO_2 values.

4.2 Muscle Activity

It was hypothesized in this study that the time to return to pre-kneeling baseline values for muscle activity will be task dependent. The results generally support the hypotheses, and the differences in time were statistically significant for the RVL, RGM, RGL, RRA, LRA, RES, RVM, and RRF muscles. However, the post-kneeling task leading to the fastest recovery time varied by muscle. This is because the performance of the three post-kneeling tasks require the activation of different muscles (Table 6), either for providing stability or in aiding in generating the movement of the respective joint(s). It is important to note that for both RMS and MDF all muscles were able to return to their pre-kneeling baseline conditions within 3 minutes while performing any of the post-kneeling tasks.

Table 6: Most active muscles per post-kneeling task

Muscle	Sit (Okada, 1972)	Stand (Okada, 1972)	Walk (Winter et al., 1987)
RTA		✔	✔
RGM		✔	✔
RGL		✔	✔
RVL		✔	
RVM	✔		
RRF	✔	✔	
RRA			
LRA			
RES	✔		
LES	✔		

Previous research (Winter et al., 1987) has shown that the most active muscles while walking are the distal support muscles (RTA, RMG, RGL) while the proximal are the least active (RES, LES, RRA, LRA), and the biarticular muscles (RRF, RBF) are the ones that exhibit the greatest variability. For the lower leg muscles (RTA, RMG, and RGL), since oxygenation was most restricted during kneeling in the lower leg, a dynamic task such as walking generates more blood flow to the lower leg muscles, leading to faster recovery. Research has shown that by generating muscular contractions at a certain dynamic frequency and duration can lead to increased intramuscular pressure, causing increased vasodilatation (Laughlin, 1987) and thus generating more muscle oxygenation.

The lower leg muscles (RTA, RMG, and RGL) are also used for maintaining stability during static tasks such as standing (Hodges et al., 1997). The static nature of

the task could be a reason why standing is the task that needs the most time to return to pre-kneeling baseline values.

The RVL and RVM muscles are at rest when the subject is sitting, but when the subject is standing or walking, these muscles are being used to generate the gait or to maintain stability (Winter et al., 1987). The resting of these muscles, without restricting oxygenation, may be the reason why sitting is more efficient in ensuring fast recovery.

The abdominal and spinal muscles have an essentially equal time to return to pre-kneeling baseline values for the 3 different post-kneeling tasks. Even though values were close together, the sitting task showed the fastest time to return to pre-kneeling baseline values for the abdominal muscles. It has been shown that the spinal muscles (RES and LES) are more active while standing (O'Sullivan et al., 2002; Okada 1972) and in this study they had the longest time to return to baseline values during standing. This is likely due to the fact that these muscles provide stability to the trunk, essentially working isometrically. Even though ES muscles are more active while kneeling, there is no blood flow restriction that would generate a longer time to return to pre-kneeling baseline values.

The RRF muscle had the most equal values for the 3 different post-kneeling tasks, with a probability of 90% or greater to return to pre-kneeling baseline values between 110 and 120 seconds. This may indicate that, for this muscle, the worker is free to sit, walk, or stand for 2 minutes in order to return to their pre-kneeling baseline values. Previous research has shown that after fatiguing the RF muscle, the RMS and MDF return to pre-fatigue state within a short period of time (Zhang et al., 1996).

However, the study does not specify the amount of time required to return to pre-fatigue values.

The same way that different muscles are used during different post-kneeling tasks, there are different muscles that are used for maintaining full flexion kneeling posture (Table 7), which may also affect the way muscles recovery, given that some muscles fatigue more than others.

Table 7: Muscles active while kneeling

Muscle	Kneeling (Okada, 1972)	End of kneeling (This study)
RTA	✔	✔
RGM		✔
RGL		
RVL		
RVM	✔	✔
RRF	✔	
RRA		
LRA		
RES	✔	✔
LES	✔	✔

When looking at the group of muscles as a whole, we are able to see that walking is the most efficient post-kneeling task to return to pre-kneeling baseline values in the fastest way. However, for any of the post-kneeling tasks the longest time to recovery is between 200 and 210 seconds for RMS and 200 and 220 seconds for MDF. This 10 and 20 second difference is not major, so it will be up to the worker to choose the task that they prefer. Decisions on which post-kneeling task to undertake may also

be dictated by proceeding activities following kneeling, and the muscles are most important for quickly return to pre-kneeling conditions.

There are no specific guidelines or standards currently in use on what to do after prolonged kneeling in order to recover. It has only been indicated to avoid prolonged kneeling and to take short frequent rests (OSHA, 2005; NIOSH, 2007). From field observations by this research team, most workers continue with their normal tasks after kneeling, and therefore increasing their risk of falling or sustaining an injury (Sharrard, 1964; Rytter et al., 2009; McMillan et al., 2005; Coggon et al., 2000; Lau et al., 1999). According to this research, in order to safely continue with their tasks, workers should rest (sit, walk, or stand) for a few minutes before returning to their regular tasks.

4.3 Range of Motion

It was hypothesized that ROM at the end of the post-kneeling task will be equal to the pre-kneeling ROM values. The results indicated that there is no significant difference between the ROM values before kneeling and after completing the post-kneeling task.

When a person is kneeling, due to the knees and ankles being bent, muscles and ligaments are being stretched and this stretch may produce a greater ROM (Feland et al., 2001). Research has shown that after stretching the knee joint and then followed by a resting period, the ROM returned to its original value, indicating that there is no retention of the stretching effects (Willy et al., 2001). Therefore, by having the subject

perform a different activity other than kneeling, the muscles and ligaments are allowed to regain the characteristics they had before the kneeling task.

4.4 Limitations

There are a few limitations that could restrict the applicability or affect the outcomes of this study. First, the testing trials were done in a laboratory environment, which does not completely replicate what workers do while they kneel in the field. For example, in a laboratory environment subjects were not performing any activity other than just kneeling, while people that practice occupational kneeling have to work with their hands or even move their body.

Another limitation in this study is the experience of the subjects; the study population was mostly students from the university, and the lack of experience in occupational kneeling may have affected the duration the subjects were kneeling. The use of experienced subjects and performing typical work activities while kneeling could better represent the real-world task.

One last limitation in this study is having only unilateral data for muscle activity and muscle oxygenation. With measurements from only one leg it was assumed that the results for these two biomarkers are symmetrical for the left and the right side. Since the task was symmetric, the assumption may be correct, and may not affect the results of the study.

5. Conclusion

The main goal of this study was to compare three different post-kneeling tasks (sit, walk, and stand) and identify which of these tasks was the most effective at promoting recovery to pre-kneeling conditions. The biomechanical evaluation results revealed that:

- The limiting bio-marker for time to return to pre-kneeling baseline values is muscle oxygenation.
- To achieve full return to pre-kneeling baseline values of muscle oxygenation and muscle activity, it is recommended that workers walk or sit for 9 minutes, or stand for 11 minutes.
- Differences between pre-kneeling and post-kneeling values for ROM in each of the post-kneeling tasks were minimal, which indicated that recovery was achieved.

Overall walking and sitting post-kneeling tasks resulted in shorter times to return to pre-kneeling baseline values. However walking poses a different challenge, because other risks may come into play. For example, the surface on which the worker is performing the task may have gravel, or be slippery, and muscle being fatigue following kneeling may increase the chances of falling or tripping. If workers have space available to sit, they should do so for at least 9 minutes in order to achieve full return to pre-kneeling baseline values. Standing was found to be the least efficient task, having the

longest times to return to pre-kneeling baseline values for both muscle oxygenation and muscle activity.

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7. Appendices

Appendix A: Time series-Time to return to pre-kneeling baseline values for muscle oxygenation

Table 8: Sitting time to return to pre-kneeling baseline values for the TA muscle - rSO_2 normalized per minute

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.0	1.0	0.9	0.9	0.9	1.0	0.9	1.0	1.0	1.0	0.9	0.9	0.9	1.1	1.0	1.0
2	0.0	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.0							
3	1.2	1.4	1.4	1.3	1.2	1.2	1.3	1.2	1.1	1.1	1.1	1.1	1.0	1.1	1.0	1.3
4	0.7	1.2	1.0	1.1	1.1	1.0	1.0	1.0	0.9	1.0	0.9	0.9	1.0	0.9	0.9	0.9
5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0								
6	0.8	1.1	1.1	1.1	1.1	1.0	1.1									
7	0.6	1.1	1.1	1.2	1.0	1.0	1.0	1.0	1.0	1.0						
8	0.2	0.9	1.0	1.0	0.9											
9	0.2	1.6	1.5	1.3	1.3	1.2	1.1	1.0	1.1	1.0	0.9	1.2	1.0	1.0	1.0	1.0
10	0.1	1.4	1.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0				
11	0.0	1.0	0.4	0.2	0.1	0.2	0.1	0.0	0.3	0.0	0.0	0.2	0.0	0.1	0.0	0.0
12	0.3	1.1	1.0	1.0	1.0											
13	0.6	1.4	1.4	1.3	1.3	1.2	1.1	1.3	1.1	1.1						
14	0.4	0.9	0.9	0.9	0.9	0.9	0.9	1.0	0.9							
15		1.4	1.5	1.3	1.2	1.2	1.2	1.2	1.1	1.1						
16	0.2	1.2	1.2	1.1	1.1	1.1										
17	0.8	1.2	1.1	1.1	1.0	1.1	1.0	1.0								
18	0.1	1.1	0.8	0.8	0.7	0.8	0.8	0.8	0.9	0.9	0.8	0.8	0.9			
19	1.0	1.2	1.1	1.1	1.1	1.0	1.0	1.1	1.1	1.1	1.1	1.0				
AVG	**0.5**	**1.2**	**1.1**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**0.9**	**0.8**	**0.8**	**0.8**	**0.8**	**0.8**	**0.8**
SD	**0.4**	**0.2**	**0.2**	**0.3**	**0.2**	**0.2**	**0.3**	**0.3**	**0.2**	**0.3**	**0.3**	**0.4**	**0.4**	**0.4**	**0.4**	**0.5**

Table 9: Walking time to return to pre-kneeling baseline values for the TA muscle - rSO_2 normalized per minute

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.2	1.0	1.0													
2	1.0	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0							
3	1.1	1.0	1.0	1.0	1.1	1.1	0.2	0.3	0.0	0.0	0.0	0.0	1.3	1.3	1.2	1.2
4	1.4	1.4	1.2	1.1	0.9	0.8	1.0	0.9	0.9	1.0	0.9	1.0	1.0	1.0	1.1	1.0
5	0.9	1.1	1.1	1.0	1.0	1.0										
6	0.9	1.0	1.1	1.1	1.0	1.0	1.0	1.0								
7	0.5	1.0	1.1	1.1	1.1	1.0	1.0	1.0	1.0							
8	0.3	0.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
9	0.3	1.6	1.5	1.5	1.4	1.1	1.1	1.2	1.2	1.1	1.1	1.0	1.3	1.2		
10	0.1	1.7	1.6	1.3	1.2	1.0	1.0	1.0	0.8	1.1	1.0	0.9	1.1	1.0	1.1	1.1
11	0.6	2.6	2.7	2.5	2.1	1.8	1.2	0.9	1.2	0.9	0.5	0.9				
12	0.3	1.0	1.0	1.0	1.1	1.0										
13	0.5	1.2	1.3	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0					
14	0.6	1.1	1.1	1.1	1.1	1.1	1.0	1.0								
15	0.0	1.0	1.1	1.1	1.0	1.0	1.0	1.0	0.9	1.0	1.0	1.0	1.1	1.0	1.0	1.0
16	0.1	1.1	1.1	1.0	1.0	1.0										
17	0.1	1.1	1.2	1.2	1.1	1.1	1.1	1.1	1.1							
18	0.0	1.5	1.2	1.1	1.1	1.2	1.1	1.2	1.1	1.1	1.1	1.1	1.1	1.3		
19	0.9	0.9	0.9	0.9	0.9	1.0	0.9	0.9	1.1	1.0	1.0	1.0	0.9	1.1	1.0	1.0
AVG	**0.6**	**1.2**	**1.2**	**1.2**	**1.1**	**1.1**	**1.0**	**1.0**	**0.9**	**0.9**	**0.9**	**0.9**	**1.1**	**1.1**	**1.1**	**1.0**
SD	**0.4**	**0.4**	**0.4**	**0.3**	**0.3**	**0.2**	**0.2**	**0.2**	**0.3**	**0.3**	**0.3**	**0.3**	**0.1**	**0.1**	**0.1**	**0.1**

Table 10: Standing time to return to pre-kneeling baseline values for the TA muscle - rSO_2 normalized per minute

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.1	1.0	1.0	1.0	1.0	0.9	0.9	0.9	1.0	1.0						
2	0.8	1.1	1.0	1.0	1.0	1.0										
3	1.4	1.5	1.4	1.2	1.2	1.2	1.0	1.2	1.1	1.1	1.3	1.2	1.2	1.1	1.1	
4	1.6	1.6	1.3	1.2	1.1	0.8	1.2	1.2	1.0	1.1	1.2	1.6	1.5	1.5	1.5	1.3
5	1.1	1.0	1.1	1.0	1.0	1.0	0.9	0.9	1.0	1.1	1.1	1.0	1.1	1.1	1.1	1.1
6	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
7	0.5	1.1	1.2	1.2	1.1	1.1	1.2	1.1	1.1	1.1	1.0	1.1	1.0	1.0	1.0	1.0
8	0.9	1.0	1.0	1.0	0.9	1.0	0.9	0.9	0.9	0.9	0.9	1.0	1.1	1.1	1.1	1.1
9	0.8	2.0	1.6	1.3	1.4	1.3	1.1	1.3	1.0	1.6	1.1	1.5	1.5	1.4	1.4	1.4
10	0.8	4.1	3.0	1.7	1.7	1.3	1.8	2.0	1.9	1.3	2.2	2.9	2.8	2.9	3.0	3.0
11	0.5	2.1	1.2	0.3	0.2	0.0	0.0	0.1	0.0	0.1	0.0	1.1	0.9	1.0	0.8	0.9
12	0.0	1.2	1.1	1.0	1.0	1.0	1.0	1.0	0.9	1.0	1.0	1.0	1.1	1.1	1.1	1.1
13	0.6	1.5	1.5	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.1	1.2	1.2	1.2	1.2
14	1.0	1.3	1.3	1.2	1.1	1.0	1.0	1.0	1.1	1.0	1.0	1.0				
15	0.4	1.2	1.2	1.1	1.0	1.0	1.0	1.0	0.9	0.9	0.9	1.1	1.0	1.0	1.0	1.0
16	0.1	1.4	1.3	1.1	1.0	1.0	1.0	1.0	1.0							
17	0.7	1.2	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	0.9	1.1	1.0	1.0	1.1	1.1
18	0.2	1.6	1.3	1.1	1.0	0.9	0.8	0.8	0.8	0.8	0.9	1.7	1.3	1.4	1.4	1.4
19	0.4	2.0	1.9	1.5	1.3	1.1	1.0	1.0	0.9	1.0	0.8	1.3	1.2	1.3	1.3	1.2
AVG	**0.7**	**1.5**	**1.3**	**1.1**	**1.1**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.3**	**1.2**	**1.3**	**1.3**	**1.3**
SD	**0.4**	**0.7**	**0.5**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.4**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**

Table 11: Sitting time to return to pre-kneeling baseline values for the MG muscle - rSO_2 normalized per minute

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.0	0.9	0.9	1.0	0.9	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0
2	1.2	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0							
3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
4	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.1	1.1	1.1	1.1	1.0	1.0	1.0
5	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0								
6	0.7	1.0	1.1	1.1	1.1	1.1	1.1									
7	0.6	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1						
8	0.2	0.8	0.9	0.9	0.9											
9	0.9	1.1	1.0	0.9	0.9	0.9	0.9	0.9	0.9	1.0	0.9	0.9	0.9	1.0	0.9	1.0
10	1.1	1.2	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.9				
11	0.1	0.9	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.7	0.7	0.8	0.7	0.8	0.7	0.8
12	0.9	1.3	1.3	1.3	1.3											
13	1.2	1.2	0.9	0.9	0.9	1.0	1.0	1.0	0.9	0.9						
14	0.6	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0							
15		1.9	2.0	1.8	1.7	1.6	1.5	1.5	1.4	1.4						
16	0.4	1.1	1.0	1.0	1.0	1.0										
17	1.1	1.1	1.0	1.1	1.1	1.1	1.1	1.1								
18	0.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0			
19	0.9	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0				
AVG	**0.8**	**1.1**	**1.1**	**1.1**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**0.9**	**1.0**	**0.9**	**1.0**
SD	**0.4**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.1**	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**

Table 12: Walking time to return to pre-kneeling baseline values for the MG muscle - rSO_2 normalized per minute

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0.99	0.96	0.99													
2	1.06	1.11	1.09	1.05	1.03	1.05	1.05	1.05	1.07							
3	1.03	0.99	0.98	1.00	1.00	0.98	0.92	1.11	0.98	0.95	0.93	1.00	1.08	1.03	1.06	1.06
4	1.13	1.05	1.08	1.04	1.08	1.08	1.08	1.05	1.05	1.05	1.07	1.07	1.07	1.08	1.08	1.09
5	1.02	1.07	1.06	1.04	1.03	1.04										
6	0.76	1.08	1.16	1.19	1.16	1.16	1.16	1.16								
7	0.58	0.98	1.04	1.04	1.04	1.03	1.03	1.02	1.02							
8	0.21	0.99	1.06	1.00	1.00	1.00	1.02	1.03	1.00	1.02	0.99	1.00	1.03	1.03	1.03	1.02
9	1.17	1.22	1.11	1.11	1.08	1.05	1.05	0.99	1.02	1.06	0.99	1.05	1.14	1.03		
10	1.04	1.19	1.12	1.06	1.06	1.00	1.03	0.99	1.00	1.03	1.08	1.04	1.06	1.06	1.07	1.10
11	0.80	1.15	1.06	1.08	0.99	1.04	1.03	0.87	0.88	1.01	0.99	1.06				
12	0.98	1.05	1.00	1.04	1.10	1.07										
13	0.14	1.54	1.64	1.37	1.29	1.09	1.17	0.96	1.13	1.11	1.02					
14	0.69	1.03	1.06	1.06	1.05	1.05	1.06	1.06								
15	0.03	1.26	1.42	1.27	1.18	1.16	1.18	1.16	1.11	1.08	1.18	1.11	1.18	1.18	1.13	1.19
16	0.25	1.10	1.07	1.05	0.99	1.01										
17	1.00	0.79	1.05	1.07	1.10	1.13	1.10	1.15	1.12							
18	0.92	1.02	1.05	1.07	1.03	1.02	1.03	1.01	1.03	1.06	1.03	1.01	1.02	1.07		
19	1.01	1.02	1.01	1.02	1.04	1.01	1.02	1.01	1.01	1.03	1.02	1.03	1.01	1.03	1.03	1.03
AVG	**0.78**	**1.08**	**1.11**	**1.09**	**1.07**	**1.05**	**1.06**	**1.04**	**1.03**	**1.04**	**1.03**	**1.04**	**1.07**	**1.06**	**1.07**	**1.08**
SD	**0.36**	**0.15**	**0.16**	**0.1**	**0.08**	**0.05**	**0.07**	**0.08**	**0.07**	**0.04**	**0.07**	**0.04**	**0.06**	**0.05**	**0.04**	**0.06**

Table 13: Standing time to return to pre-kneeling baseline values for the MG muscle - rSO_2 normalized per minute

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.13	0.99	0.97	1.00	0.94	0.95	0.94	0.97	0.97	1.00						
2	0.91	1.00	0.92	0.91	0.91	0.95										
3	1.09	1.03	1.00	0.99	1.00	1.07	1.01	1.03	1.00	0.99	1.10	1.03	1.04	1.03	1.06	
4	0.93	1.18	1.15	1.13	1.15	1.06	1.09	1.06	1.06	1.03	1.02	1.15	1.12	1.10	1.12	1.09
5	1.06	1.06	1.03	1.03	1.02	1.00	0.98	0.99	0.96	0.98	0.98	1.02	1.04	1.03	1.04	1.04
6	0.91	0.92	0.91	0.91	0.88	0.87	0.85	0.84	0.82	0.84	0.81	0.82	0.81	0.82	0.82	0.81
7	0.65	0.97	1.24	1.29	1.28	1.26	1.23	1.23	1.20	1.18	1.16	1.13	1.11	1.11	1.10	1.11
8	0.91	0.98	0.95	0.94	0.98	1.07	0.98	0.95	0.94	0.97	0.94	0.99	1.02	1.05	1.07	1.07
9	1.23	1.32	1.21	1.14	1.21	1.13	1.16	1.11	1.00	1.13	0.98	1.03	1.27	1.11	1.13	1.14
10	1.16	1.12	1.06	0.98	0.96	0.99	1.01	1.06	1.06	1.02	1.02	0.99	0.96	1.01	1.06	1.04
11	0.51	1.01	0.61	0.84	0.91	0.92	0.91	0.85	0.99	0.96	0.78	1.13	0.84	0.80	0.73	0.73
12	1.07	1.33	1.23	1.24	1.28	1.19	1.12	1.09	1.07	1.05	1.07	1.16	1.14	1.16	1.14	1.14
13	0.65	3.32	2.58	2.03	1.24	1.47	0.74	0.51	1.34	1.47	1.52	1.38	1.11	1.11	1.24	1.34
14	1.08	1.09	1.09	1.09	1.08	1.06	1.06	1.02	0.98	0.96	0.92	0.89				
15	0.00	1.17	1.28	1.15	1.15	0.93	1.04	0.96	0.96	0.96	0.89	1.09	0.95	0.95	0.95	0.91
16	0.31	1.12	1.00	0.98	0.92	0.89	0.87	0.87	0.85							
17	1.48	0.91	0.97	1.01	0.97	0.97	0.91	0.93	0.79	0.83	0.89	1.30	1.16	1.18	1.20	1.22
18	0.64	1.12	1.14	1.23	1.22	1.14	0.93	1.04	0.96	1.07	1.01	1.06	1.03	1.03	1.03	1.06
19	1.23	1.20	1.14	1.12	1.12	1.06	1.04	1.01	1.01	1.01	0.98	1.06	1.04	1.04	1.06	1.02
AVG	**0.89**	**1.20**	**1.13**	**1.11**	**1.06**	**1.05**	**0.99**	**0.97**	**1.00**	**1.03**	**1.00**	**1.08**	**1.04**	**1.04**	**1.05**	**1.05**
SD	**0.36**	**0.53**	**0.38**	**0.26**	**0.14**	**0.15**	**0.12**	**0.15**	**0.13**	**0.14**	**0.17**	**0.14**	**0.12**	**0.11**	**0.13**	**0.16**

Appendix B: Rate of recovery and time to return to pre-kneeling baseline values for RMS per muscle and task

Table 14: Time to return to pre-kneeling baseline values for sitting task for the RVL muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.011	0.005	0.004	0.002	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.002	0.001	0.001
2	0.440	0.221	0.148	0.109	0.089	0.074	0.063	0.055	0.049	0.044	0.040	0.037	0.034	0.032	0.029	0.028	0.026	0.025
3	0.018	0.005	0.001	0.011	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002
4	0.014	0.003	0.003	0.002	0.001	0.002	0.003	0.003	0.002	0.002	0.002	0.002	0.003	0.002	0.001	0.001	0.002	0.001
5	0.014	0.015	0.013	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.097	0.030	0.012	0.008	0.005	0.004	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001
7	0.297	0.101	0.038	0.017	0.009	0.007	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.060	0.011	0.001	0.001	0.002	0.003	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001
9	0.006	0.007	0.008	0.007	0.006	0.005	0.005	0.004	0.004	0.003	0.003	0.003	0.003	0.002	0.012	0.013	0.011	0.007
10	0.029	0.006	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
11	0.034	0.005	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001
12	0.109	0.050	0.042	0.033	0.027	0.020	0.019	0.018	0.016	0.015	0.011	0.012	0.011	0.010	0.010	0.009	0.009	0.008
13	0.020	0.007	0.005	0.003	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
14																		
15	0.021	0.004	0.001	0.001	0.001	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
16	0.021	0.010	0.007	0.005	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.002	0.001	0.001	0.001
17	0.013	0.007	0.004	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
18	0.028	0.009	0.000	0.002	0.007	0.008	0.009	0.009	0.009	0.008	0.008	0.007	0.007	0.006	0.006	0.006	0.005	0.005
19	0.016	0.012	0.009	0.008	0.003	0.004	0.005	0.006	0.004	0.006	0.005	0.006	0.004	0.008	0.007	0.006	0.012	0.003
Average	0.069	0.028	0.017	0.012	0.009	0.008	0.007	0.006	0.006	0.005	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.003
St. Dev.	0.115	0.054	0.035	0.025	0.021	0.017	0.015	0.013	0.012	0.010	0.009	0.009	0.008	0.007	0.007	0.007	0.007	0.006

Table 15: Time to return to pre-kneeling baseline values for walking task for the RVL muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.115	0.043	0.019	0.013	0.011	0.009	0.009	0.008	0.007	0.005	0.006	0.005	0.006	0.005	0.005	0.002	0.002	0.002
2	0.080	0.036	0.024	0.018	0.016	0.012	0.010	0.009	0.008	0.007	0.006	0.006	0.005	0.005	0.005	0.005	0.004	0.004
3	0.081	0.037	0.021	0.015	0.013	0.012	0.008	0.005	0.006	0.005	0.003	0.004	0.003	0.004	0.003	0.003	0.002	0.002
4	0.077	0.034	0.025	0.014	0.011	0.009	0.007	0.006	0.005	0.005	0.005	0.004	0.005	0.005	0.004	0.003	0.003	0.003
5	0.076	0.035	0.018	0.022	0.012	0.005	0.008	0.007	0.003	0.005	0.005	0.005	0.002	0.005	0.004	0.004	0.003	0.002
6	0.368	0.135	0.065	0.036	0.023	0.012	0.005	0.001	0.003	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.003
7	0.049	0.020	0.014	0.010	0.008	0.006	0.004	0.003	0.004	0.004	0.003	0.003	0.003	0.003	0.002	0.002	0.001	0.002
8	0.026	0.015	0.013	0.008	0.013	0.007	0.003	0.004	0.003	0.003	0.002	0.003	0.002	0.001	0.001	0.001	0.001	0.001
9	0.082	0.043	0.026	0.017	0.016	0.012	0.011	0.011	0.009	0.006	0.006	0.005	0.004	0.004	0.003	0.004	0.003	0.003
10	0.084	0.030	0.024	0.011	0.007	0.008	0.004	0.003	0.004	0.002	0.001	0.002	0.002	0.001	0.003	0.002	0.001	0.001
11	0.073	0.036	0.076	0.045	0.019	0.019	0.012	0.011	0.008	0.008	0.007	0.007	0.006	0.006	0.005	0.005	0.005	0.004
12	0.068	0.033	0.019	0.014	0.012	0.010	0.008	0.007	0.006	0.006	0.005	0.005	0.005	0.004	0.003	0.004	0.003	0.003
13	0.125	0.065	0.038	0.028	0.021	0.014	0.012	0.012	0.020	0.012	0.012	0.021	0.017	0.007	0.007	0.013	0.008	0.010
14																		
15	0.157	0.131	0.044	0.037	0.025	0.018	0.014	0.010	0.009	0.008	0.008	0.006	0.006	0.006	0.005	0.005	0.004	0.004
16	0.050	0.024	0.028	0.023	0.022	0.013	0.012	0.009	0.009	0.014	0.011	0.009	0.006	0.008	0.008	0.006	0.005	0.007
17	0.100	0.040	0.022	0.016	0.018	0.011	0.011	0.008	0.007	0.006	0.005	0.005	0.004	0.004	0.004	0.003	0.003	0.003
18	0.106	0.045	0.030	0.017	0.014	0.014	0.010	0.008	0.008	0.007	0.007	0.005	0.005	0.005	0.005	0.005	0.004	0.004
19	0.172	0.067	0.048	0.027	0.026	0.018	0.027	0.015	0.014	0.008	0.005	0.004	0.003	0.003	0.003	0.003	0.002	0.003
Average	0.105	0.048	0.031	0.021	0.016	0.012	0.010	0.008	0.007	0.006	0.006	0.006	0.005	0.004	0.004	0.004	0.003	0.003
St. Dev.	0.075	0.033	0.017	0.010	0.006	0.004	0.005	0.004	0.004	0.003	0.003	0.004	0.003	0.002	0.002	0.003	0.002	0.002

Table 16: Time to return to pre-kneeling baseline values for standing task for the RVL muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.071	0.035	0.023	0.017	0.014	0.012	0.011	0.010	0.008	0.007	0.006	0.006	0.005	0.005	0.005	0.004	0.004	0.004
2	0.289	0.145	0.097	0.072	0.058	0.003	0.038	0.036	0.032	0.028	0.026	0.024	0.023	0.019	0.019	0.018	0.017	0.007
3	0.007	0.043	0.056	0.046	0.022	0.020	0.021	0.015	0.019	0.022	0.019	0.018	0.018	0.017	0.016	0.009	0.012	0.013
4	0.097	0.015	0.026	0.022	0.023	0.006	0.003	0.002	0.002	0.002	0.002	0.001	0.008	0.009	0.010	0.008	0.006	0.002
5	0.012	0.001	0.002	0.006	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000
6	0.116	0.046	0.024	0.015	0.017	0.015	0.021	0.008	0.012	0.008	0.008	0.005	0.001	0.001	0.001	0.000	0.004	0.004
7	0.208	0.042	0.004	0.007	0.003	0.009	0.014	0.014	0.008	0.009	0.011	0.007	0.006	0.008	0.009	0.009	0.009	0.009
8	0.037	0.021	0.034	0.015	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000
9	0.292	0.121	0.109	0.000	0.000	0.004	0.001	0.000	0.000	0.000	0.008	0.007	0.002	0.000	0.000	0.000	0.001	0.000
10	0.157	0.177	0.006	0.005	0.013	0.004	0.004	0.003	0.003	0.003	0.002	0.001	0.002	0.002	0.002	0.002	0.002	0.001
11	0.006	0.013	0.004	0.003	0.002	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.000
12	0.024	0.015	0.008	0.005	0.004	0.004	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
13	0.153	0.064	0.045	0.025	0.009	0.005	0.009	0.014	0.006	0.006	0.010	0.002	0.004	0.011	0.027	0.020	0.009	0.012
14																		
15	0.034	0.022	0.023	0.024	0.015	0.012	0.010	0.009	0.009	0.005	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.001
16	0.009	0.005	0.002	0.002	0.002	0.005	0.001	0.001	0.001	0.001	0.002	0.003	0.001	0.009	0.001	0.000	0.008	0.005
17	0.033	0.020	0.014	0.007	0.020	0.011	0.009	0.004	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
18	0.133	0.033	0.024	0.012	0.008	0.008	0.002	0.001	0.001	0.001	0.000	0.001	0.000	0.000	0.001	0.000	0.001	0.001
19	0.248	0.072	0.063	0.040	0.031	0.026	0.017	0.008	0.008	0.006	0.008	0.009	0.004	0.000	0.003	0.002	0.001	0.001
Average	**0.107**	**0.049**	**0.031**	**0.018**	**0.014**	**0.008**	**0.009**	**0.007**	**0.007**	**0.006**	**0.006**	**0.005**	**0.005**	**0.005**	**0.006**	**0.004**	**0.004**	**0.003**
St. Dev.	**0.099**	**0.050**	**0.032**	**0.018**	**0.014**	**0.007**	**0.010**	**0.009**	**0.008**	**0.008**	**0.007**	**0.006**	**0.006**	**0.006**	**0.008**	**0.006**	**0.005**	**0.004**

Table 17: Time to return to pre-kneeling baseline values for sitting task for the RTA muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.215	0.095	0.079	0.044	0.046	0.032	0.032	0.027	0.024	0.014	0.019	0.017	0.016	0.011	0.015	0.012	0.011	0.011
2	1.223	0.611	0.413	0.246	0.248	0.207	0.176	0.155	0.135	0.122	0.109	0.104	0.096	0.089	0.083	0.078	0.073	0.069
3	0.142	0.257	0.179	0.054	0.115	0.105	0.090	0.079	0.071	0.064	0.058	0.053	0.049	0.046	0.043	0.040	0.038	0.035
4	0.112	0.028	0.009	0.002	0.009	0.008	0.010	0.011	0.009	0.010	0.009	0.007	0.007	0.007	0.007	0.008	0.007	0.007
5	0.327	0.148	0.091	0.011	0.008	0.007	0.008	0.006	0.003	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.001
6	0.506	0.224	0.110	0.069	0.046	0.029	0.019	0.014	0.012	0.011	0.010	0.009	0.008	0.007	0.007	0.006	0.006	0.005
7	0.259	0.179	0.051	0.075	0.042	0.025	0.025	0.024	0.016	0.018	0.014	0.014	0.011	0.037	0.041	0.028	0.014	0.014
8	0.144	0.081	0.056	0.042	0.034	0.029	0.025	0.022	0.020	0.018	0.017	0.016	0.014	0.013	0.012	0.012	0.011	0.010
9	0.306	0.169	0.097	0.094	0.077	0.065	0.056	0.049	0.021	0.040	0.036	0.033	0.030	0.028	0.026	0.025	0.023	0.022
10	2.938	1.478	0.985	0.743	0.596	0.498	0.428	0.376	0.335	0.302	0.275	0.252	0.233	0.216	0.202	0.189	0.178	0.168
11	0.022	0.016	0.012	0.006	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	0.193	0.077	0.039	0.020	0.014	0.017	0.007	0.002	0.001	0.001	0.008	0.002	0.000	0.000	0.000	0.001	0.000	0.001
13	0.156	0.048	0.026	0.013	0.006	0.003	0.003	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001
14																		
15	0.014	0.007	0.007	0.002	0.001	0.004	0.002	0.001	0.001	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.317	0.243	0.153	0.122	0.098	0.081	0.070	0.061	0.055	0.049	0.044	0.040	0.038	0.035	0.028	0.030	0.029	0.027
17	0.040	0.023	0.014	0.010	0.007	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.001	0.001	0.001
18	0.484	0.134	0.057	0.032	0.015	0.007	0.002	0.000	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001
19	1.678	0.832	0.552	0.411	0.335	0.280	0.241	0.212	0.189	0.170	0.155	0.142	0.131	0.122	0.113	0.106	0.100	0.095
Average	**0.504**	**0.258**	**0.163**	**0.111**	**0.094**	**0.078**	**0.067**	**0.058**	**0.050**	**0.046**	**0.042**	**0.039**	**0.036**	**0.034**	**0.032**	**0.030**	**0.028**	**0.026**
St. Dev.	**0.743**	**0.372**	**0.251**	**0.188**	**0.154**	**0.130**	**0.112**	**0.098**	**0.088**	**0.079**	**0.071**	**0.066**	**0.061**	**0.056**	**0.052**	**0.049**	**0.046**	**0.044**

Table 18: Time to return to pre-kneeling baseline values for walking task for the RTA muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.092	0.040	0.025	0.020	0.017	0.014	0.010	0.012	0.008	0.007	0.007	0.006	0.007	0.010	0.008	0.004	0.001	0.001
2	0.010	0.011	0.007	0.007	0.005	0.003	0.002	0.003	0.002	0.002	0.003	0.002	0.002	0.002	0.001	0.002	0.002	0.001
3	0.005	0.002	0.005	0.001	0.001	0.001	0.000	0.001	0.002	0.001	0.001	0.000	0.001	0.000	0.001	0.001	0.000	0.001
4	0.001	0.002	0.003	0.005	0.001	0.003	0.001	0.001	0.001	0.001	0.000	0.000	0.001	0.000	0.002	0.000	0.000	0.000
5	0.105	0.044	0.030	0.020	0.017	0.015	0.012	0.011	0.009	0.008	0.009	0.008	0.006	0.006	0.005	0.005	0.005	0.004
6	0.269	0.110	0.067	0.045	0.035	0.026	0.023	0.019	0.015	0.013	0.011	0.009	0.009	0.007	0.006	0.006	0.006	0.006
7	0.096	0.052	0.033	0.027	0.019	0.013	0.013	0.012	0.012	0.010	0.009	0.009	0.008	0.007	0.006	0.006	0.006	0.007
8	0.113	0.054	0.029	0.017	0.020	0.012	0.009	0.010	0.008	0.008	0.008	0.007	0.007	0.005	0.006	0.005	0.004	0.003
9	0.000	0.003	0.006	0.004	0.004	0.003	0.001	0.001	0.002	0.003	0.003	0.002	0.002	0.002	0.002	0.001	0.002	0.002
10	0.053	0.039	0.024	0.018	0.014	0.008	0.007	0.007	0.005	0.005	0.004	0.002	0.006	0.002	0.003	0.004	0.002	0.000
11	0.047	0.025	0.025	0.016	0.009	0.007	0.005	0.006	0.004	0.003	0.002	0.003	0.003	0.004	0.003	0.003	0.002	0.002
12	0.085	0.050	0.032	0.024	0.020	0.015	0.014	0.011	0.012	0.010	0.009	0.006	0.008	0.007	0.006	0.005	0.005	0.005
13	0.095	0.042	0.025	0.021	0.023	0.016	0.016	0.012	0.012	0.011	0.009	0.009	0.008	0.008	0.007	0.007	0.006	0.006
14																		
15	0.123	0.064	0.031	0.024	0.016	0.015	0.016	0.012	0.012	0.011	0.011	0.011	0.012	0.009	0.008	0.008	0.007	0.007
16	0.043	0.032	0.015	0.015	0.010	0.009	0.008	0.008	0.009	0.008	0.006	0.005	0.004	0.005	0.004	0.004	0.003	0.004
17	0.071	0.093	0.062	0.024	0.018	0.015	0.013	0.011	0.009	0.008	0.008	0.006	0.006	0.006	0.006	0.005	0.005	0.004
18	0.180	0.091	0.059	0.043	0.037	0.031	0.029	0.025	0.022	0.020	0.018	0.017	0.017	0.014	0.013	0.013	0.011	0.011
19	0.019	0.006	0.000	0.004	0.004	0.002	0.003	0.002	0.001	0.003	0.005	0.003	0.002	0.002	0.001	0.002	0.001	0.001
Average	0.078	0.042	0.026	0.019	0.015	0.011	0.010	0.009	0.008	0.007	0.007	0.006	0.006	0.005	0.005	0.005	0.004	0.004
St. Dev.	0.069	0.032	0.020	0.012	0.010	0.008	0.008	0.006	0.006	0.005	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.003

Table 19: Time to return to pre-kneeling baseline values for standing task for the RTA muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.108	0.057	0.045	0.034	0.023	0.018	0.012	0.007	0.013	0.012	0.011	0.011	0.010	0.008	0.008	0.007	0.006	0.007
2	1.164	0.531	0.382	0.286	0.251	0.217	0.131	0.108	0.127	0.108	0.121	0.111	0.103	0.095	0.085	0.081	0.074	0.059
3	1.007	0.462	0.345	0.260	0.208	0.174	0.149	0.131	0.116	0.105	0.095	0.087	0.081	0.075	0.070	0.063	0.062	0.058
4	0.100	0.029	0.026	0.020	0.014	0.011	0.010	0.012	0.009	0.008	0.008	0.006	0.004	0.006	0.002	0.001	0.001	0.001
5	0.162	0.013	0.009	0.016	0.005	0.003	0.009	0.005	0.006	0.009	0.002	0.001	0.002	0.001	0.004	0.001	0.001	0.001
6	0.059	0.003	0.000	0.002	0.019	0.019	0.021	0.004	0.010	0.001	0.001	0.000	0.000	0.000	0.002	0.001	0.001	0.001
7	0.184	0.126	0.127	0.136	0.111	0.099	0.074	0.038	0.035	0.026	0.024	0.017	0.023	0.013	0.010	0.009	0.007	0.006
8	7.074	3.537	2.358	1.769	1.415	1.097	0.947	0.842	0.757	0.683	0.625	0.575	0.533	0.497	0.463	0.435	0.410	0.389
9	0.115	0.054	0.036	0.014	0.008	0.003	0.001	0.001	0.001	0.001	0.006	0.013	0.001	0.001	0.001	0.001	0.001	0.001
10	0.594	0.308	0.220	0.164	0.126	0.112	0.096	0.084	0.075	0.067	0.061	0.057	0.052	0.049	0.046	0.043	0.040	0.037
11	0.295	0.132	0.086	0.076	0.060	0.050	0.043	0.037	0.033	0.030	0.027	0.025	0.023	0.021	0.020	0.019	0.018	0.017
12	0.155	0.072	0.059	0.007	0.022	0.019	0.001	0.001	0.006	0.004	0.003	0.001	0.001	0.001	0.002	0.001	0.001	0.001
13	0.232	0.069	0.021	0.011	0.006	0.004	0.004	0.003	0.003	0.003	0.023	0.002	0.041	0.007	0.002	0.031	0.007	0.009
14																		
15	0.143	0.077	0.055	0.046	0.037	0.032	0.027	0.023	0.023	0.021	0.019	0.017	0.015	0.013	0.013	0.012	0.011	0.011
16	0.518	0.259	0.171	0.129	0.104	0.086	0.074	0.064	0.057	0.052	0.047	0.043	0.040	0.036	0.034	0.032	0.029	0.028
17	0.049	0.032	0.032	0.010	0.011	0.009	0.009	0.004	0.004	0.004	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.003
18	0.204	0.016	0.080	0.025	0.019	0.011	0.006	0.004	0.004	0.003	0.002	0.012	0.002	0.002	0.002	0.002	0.002	0.001
19	0.059	0.030	0.017	0.013	0.012	0.007	0.005	0.006	0.006	0.005	0.005	0.004	0.003	0.003	0.002	0.002	0.001	0.001
Average	0.679	0.323	0.226	0.168	0.136	0.110	0.090	0.076	0.071	0.063	0.060	0.055	0.052	0.046	0.043	0.041	0.038	0.035
St. Dev.	1.628	0.817	0.544	0.409	0.327	0.254	0.219	0.195	0.175	0.158	0.145	0.134	0.124	0.116	0.108	0.101	0.095	0.090

Table 20: Time to return to pre-kneeling baseline values for sitting task for the RGM muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.089	0.047	0.036	0.024	0.020	0.017	0.014	0.013	0.011	0.011	0.010	0.009	0.009	0.010	0.008	0.010	0.010	0.007
2	0.003	0.002	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.058	0.018	0.003	0.003	0.007	0.009	0.010	0.009	0.009	0.009	0.009	0.008	0.008	0.008	0.007	0.007	0.006	0.006
4	0.244	0.124	0.076	0.055	0.040	0.029	0.025	0.023	0.023	0.024	0.017	0.016	0.012	0.011	0.008	0.007	0.007	0.006
5	0.014	0.003	0.004	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
6	0.068	0.027	0.013	0.010	0.006	0.004	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001
7	0.348	0.131	0.066	0.018	0.008	0.006	0.003	0.002	0.002	0.001	0.001	0.001	0.000	0.001	0.001	0.000	0.000	0.000
8	0.014	0.008	0.005	0.004	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000
9	0.116	0.045	0.027	0.013	0.008	0.004	0.001	0.000	0.000	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001
10	0.085	0.039	0.016	0.051	0.004	0.020	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002
11	0.007	0.001	0.002	0.000	0.001	0.001	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	0.111	0.054	0.035	0.026	0.020	0.017	0.014	0.012	0.011	0.010	0.009	0.008	0.007	0.007	0.006	0.006	0.006	0.005
13	0.026	0.004	0.004	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
14																		
15	0.123	0.073	0.037	0.030	0.023	0.019	0.017	0.015	0.013	0.012	0.010	0.010	0.009	0.008	0.008	0.007	0.007	0.007
16	0.005	0.002	0.018	0.004	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
17	0.026	0.009	0.011	0.004	0.002	0.002	0.002	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
18	0.199	0.070	0.062	0.047	0.015	0.004	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
19	0.158	0.070	0.045	0.037	0.019	0.046	0.012	0.004	0.003	0.002	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.000
Average	0.094	0.040	0.026	0.018	0.010	0.010	0.006	0.005	0.005	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.002	0.002
St. Dev.	0.094	0.041	0.024	0.019	0.011	0.013	0.007	0.007	0.006	0.006	0.005	0.004	0.004	0.004	0.003	0.003	0.003	0.003

Table 21: Time to return to pre-kneeling baseline values for walking task for the RGM muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.095	0.046	0.029	0.025	0.017	0.014	0.012	0.011	0.011	0.010	0.010	0.009	0.008	0.008	0.007	0.003	0.000	0.000
2	0.067	0.033	0.024	0.016	0.014	0.012	0.010	0.007	0.007	0.006	0.005	0.005	0.005	0.005	0.005	0.004	0.004	0.004
3	0.106	0.043	0.026	0.018	0.016	0.010	0.009	0.007	0.007	0.008	0.006	0.005	0.005	0.004	0.004	0.004	0.004	0.004
4	0.092	0.042	0.022	0.022	0.020	0.013	0.011	0.012	0.011	0.010	0.009	0.010	0.007	0.007	0.007	0.007	0.006	0.005
5	0.082	0.055	0.035	0.026	0.020	0.017	0.013	0.012	0.011	0.011	0.009	0.007	0.008	0.007	0.006	0.006	0.006	0.005
6	0.090	0.036	0.030	0.019	0.015	0.014	0.012	0.011	0.008	0.008	0.008	0.006	0.009	0.007	0.006	0.006	0.006	0.006
7	0.115	0.056	0.035	0.024	0.021	0.015	0.015	0.011	0.012	0.010	0.010	0.009	0.007	0.007	0.006	0.006	0.006	0.005
8	0.468	0.229	0.157	0.117	0.094	0.075	0.065	0.056	0.053	0.046	0.040	0.037	0.035	0.032	0.031	0.029	0.028	0.026
9	0.083	0.032	0.026	0.017	0.014	0.011	0.009	0.006	0.010	0.006	0.006	0.005	0.004	0.005	0.005	0.004	0.003	0.003
10	0.103	0.034	0.028	0.017	0.014	0.014	0.011	0.011	0.010	0.008	0.007	0.005	0.006	0.005	0.007	0.004	0.004	0.004
11	0.088	0.046	0.029	0.022	0.019	0.014	0.012	0.010	0.012	0.008	0.008	0.007	0.006	0.006	0.004	0.004	0.005	0.005
12	0.091	0.042	0.033	0.020	0.018	0.014	0.014	0.012	0.009	0.009	0.008	0.009	0.007	0.006	0.006	0.006	0.006	0.005
13	0.067	0.041	0.031	0.022	0.021	0.015	0.014	0.012	0.014	0.011	0.013	0.009	0.009	0.008	0.007	0.007	0.006	0.006
14																		
15																		
16	0.119	0.050	0.031	0.029	0.022	0.018	0.017	0.012	0.011	0.014	0.011	0.008	0.008	0.008	0.006	0.006	0.006	0.006
17	0.094	0.044	0.032	0.022	0.015	0.014	0.013	0.012	0.009	0.008	0.008	0.007	0.007	0.006	0.005	0.005	0.005	0.004
18	0.080	0.042	0.030	0.022	0.019	0.017	0.013	0.011	0.009	0.007	0.008	0.006	0.005	0.005	0.004	0.005	0.004	0.004
19	0.141	0.045	0.024	0.030	0.020	0.016	0.016	0.013	0.010	0.008	0.009	0.007	0.007	0.006	0.005	0.005	0.006	0.005
Average	**0.116**	**0.054**	**0.037**	**0.028**	**0.022**	**0.018**	**0.016**	**0.013**	**0.013**	**0.011**	**0.010**	**0.009**	**0.008**	**0.008**	**0.007**	**0.006**	**0.006**	**0.006**
St. Dev.	**0.093**	**0.046**	**0.031**	**0.023**	**0.019**	**0.015**	**0.013**	**0.011**	**0.010**	**0.009**	**0.008**	**0.007**	**0.007**	**0.006**	**0.006**	**0.006**	**0.006**	**0.005**

Table 22: Time to return to pre-kneeling baseline values for standing task for the RGM muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.085	0.042	0.028	0.026	0.017	0.013	0.012	0.011	0.010	0.009	0.007	0.007	0.007	0.006	0.006	0.005	0.005	0.005
2	0.185	0.067	0.069	0.023	0.035	0.036	0.007	0.012	0.006	0.012	0.007	0.010	0.006	0.014	0.009	0.008	0.005	0.007
3	0.018	0.014	0.000	0.002	0.001	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
4	0.139	0.111	0.058	0.036	0.032	0.047	0.050	0.042	0.037	0.029	0.030	0.017	0.013	0.011	0.006	0.012	0.009	0.010
5	0.006	0.008	0.001	0.012	0.002	0.001	0.007	0.001	0.002	0.005	0.005	0.003	0.003	0.001	0.003	0.015	0.018	0.020
6	0.041	0.027	0.042	0.021	0.014	0.012	0.007	0.013	0.005	0.004	0.003	0.006	0.008	0.014	0.022	0.008	0.002	0.001
7	0.187	0.089	0.065	0.049	0.033	0.017	0.014	0.014	0.019	0.011	0.007	0.008	0.007	0.004	0.004	0.003	0.006	0.005
8	0.042	0.033	0.020	0.032	0.019	0.016	0.010	0.008	0.008	0.006	0.005	0.005	0.004	0.006	0.003	0.003	0.003	0.005
9	0.082	0.034	0.020	0.016	0.033	0.015	0.024	0.016	0.022	0.017	0.003	0.001	0.003	0.004	0.009	0.010	0.010	0.008
10	0.081	0.035	0.033	0.021	0.010	0.013	0.014	0.012	0.008	0.007	0.004	0.006	0.003	0.004	0.006	0.006	0.005	0.002
11	0.094	0.062	0.043	0.021	0.017	0.015	0.012	0.011	0.010	0.009	0.008	0.008	0.007	0.006	0.006	0.006	0.005	0.005
12	0.093	0.046	0.032	0.029	0.015	0.013	0.016	0.014	0.009	0.008	0.008	0.009	0.010	0.008	0.006	0.006	0.005	0.005
13	0.134	0.090	0.042	0.032	0.016	0.018	0.015	0.008	0.009	0.008	0.007	0.006	0.007	0.005	0.005	0.004	0.004	0.004
14																		
15	0.147	0.052	0.030	0.031	0.020	0.019	0.016	0.018	0.011	0.011	0.005	0.004	0.009	0.008	0.008	0.008	0.007	0.008
16	0.067	0.039	0.029	0.030	0.022	0.014	0.012	0.012	0.013	0.012	0.007	0.006	0.009	0.006	0.006	0.007	0.004	0.004
17	0.080	0.064	0.039	0.035	0.031	0.024	0.016	0.010	0.011	0.006	0.010	0.008	0.008	0.006	0.005	0.004	0.003	0.004
18	0.038	0.060	0.038	0.025	0.015	0.013	0.012	0.011	0.008	0.007	0.006	0.008	0.008	0.007	0.007	0.005	0.004	0.004
19	0.000	0.000	0.000	0.022	0.019	0.017	0.015	0.013	0.012	0.011	0.010	0.009	0.009	0.009	0.008	0.008	0.009	0.009
Average	0.084	0.049	0.033	0.026	0.019	0.017	0.014	0.013	0.011	0.010	0.007	0.007	0.007	0.007	0.007	0.007	0.006	0.006
St. Dev.	0.056	0.029	0.020	0.010	0.010	0.011	0.010	0.009	0.008	0.006	0.006	0.004	0.003	0.004	0.004	0.003	0.004	0.004

Table 23: Time to return to pre-kneeling baseline values for sitting task for the RGL muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.013	0.007	0.005	0.004	0.004	0.005	0.003	0.004	0.003	0.004	0.002	0.002	0.002	0.003	0.002	0.002	0.002	0.009
2	0.020	0.001	0.001	0.004	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.060	0.035	0.001	0.011	0.003	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.007	0.007	0.006	0.006	0.006	0.006
4	0.038	0.015	0.009	0.004	0.003	0.004	0.004	0.003	0.005	0.003	0.006	0.003	0.001	0.001	0.000	0.000	0.001	0.000
5	0.036	0.015	0.011	0.005	0.003	0.003	0.002	0.003	0.002	0.001	0.001	0.000	0.002	0.001	0.001	0.001	0.002	0.000
6	0.076	0.037	0.023	0.016	0.013	0.010	0.009	0.007	0.007	0.006	0.006	0.005	0.005	0.004	0.004	0.004	0.003	0.003
7	0.065	0.029	0.016	0.010	0.008	0.006	0.004	0.004	0.003	0.003	0.004	0.003	0.002	0.002	0.002	0.002	0.002	0.002
8	0.013	0.006	0.004	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.091	0.044	0.039	0.012	0.004	0.001	0.004	0.006	0.006	0.007	0.007	0.007	0.006	0.006	0.006	0.005	0.005	0.005
10																		
11	0.012	0.005	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
12	0.029	0.016	0.062	0.028	0.013	0.008	0.007	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002
13	0.049	0.006	0.001	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
14																		
15	0.014	0.005	0.004	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000
16	0.192	0.080	0.029	0.011	0.002	0.001	0.000	0.000	0.000	0.001	0.000	0.002	0.000	0.001	0.000	0.001	0.001	0.001
17	0.037	0.013	0.009	0.006	0.004	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.001
18	0.023	0.015	0.016	0.014	0.012	0.010	0.009	0.008	0.008	0.007	0.007	0.006	0.006	0.005	0.005	0.005	0.005	0.004
19	0.162	0.092	0.059	0.046	0.027	0.020	0.016	0.012	0.011	0.010	0.009	0.008	0.007	0.007	0.006	0.006	0.005	0.005
Average	0.055	0.025	0.017	0.011	0.006	0.005	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002
St. Dev.	0.052	0.026	0.019	0.011	0.007	0.005	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.003

Table 24: Time to return to pre-kneeling baseline values for walking task for the RGL muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.076	0.033	0.019	0.014	0.010	0.009	0.009	0.007	0.005	0.006	0.005	0.006	0.005	0.005	0.006	0.001	0.002	0.002
2	0.065	0.036	0.023	0.017	0.015	0.011	0.009	0.008	0.007	0.006	0.006	0.005	0.005	0.005	0.005	0.004	0.003	0.004
3	0.077	0.036	0.019	0.016	0.014	0.010	0.008	0.005	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.002
4	0.051	0.021	0.006	0.006	0.004	0.006	0.006	0.002	0.005	0.005	0.003	0.004	0.003	0.004	0.003	0.003	0.001	0.002
5	0.115	0.087	0.041	0.031	0.025	0.021	0.016	0.015	0.016	0.010	0.009	0.007	0.005	0.006	0.006	0.005	0.006	0.007
6	0.074	0.045	0.030	0.024	0.019	0.013	0.013	0.009	0.010	0.009	0.006	0.008	0.008	0.007	0.006	0.005	0.007	0.004
7	0.106	0.030	0.015	0.013	0.011	0.011	0.008	0.007	0.006	0.005	0.007	0.004	0.004	0.003	0.003	0.005	0.003	0.004
8	0.129	0.057	0.040	0.023	0.023	0.014	0.014	0.012	0.007	0.008	0.005	0.005	0.007	0.005	0.004	0.003	0.002	0.002
9	0.077	0.025	0.023	0.014	0.016	0.011	0.009	0.007	0.007	0.006	0.003	0.002	0.002	0.003	0.002	0.003	0.002	0.002
10	0.458	0.157	0.087	0.056	0.017	0.018	0.008	0.009	0.004	0.001	0.001	0.002	0.014	0.001	0.021	0.009	0.004	0.007
11	0.094	0.041	0.028	0.021	0.020	0.014	0.013	0.011	0.011	0.008	0.007	0.006	0.005	0.005	0.005	0.006	0.006	0.004
12	0.105	0.041	0.025	0.015	0.013	0.011	0.012	0.010	0.007	0.007	0.007	0.006	0.005	0.006	0.005	0.006	0.004	0.004
13	0.051	0.031	0.051	0.054	0.063	0.058	0.063	0.072	0.048	0.047	0.043	0.035	0.032	0.032	0.029	0.036	0.027	0.033
14																		
15	0.069	0.029	0.016	0.010	0.009	0.008	0.009	0.009	0.008	0.008	0.008	0.008	0.008	0.007	0.006	0.005	0.005	0.005
16	0.057	0.030	0.017	0.018	0.014	0.010	0.011	0.008	0.009	0.011	0.008	0.006	0.006	0.007	0.006	0.004	0.005	0.004
17	0.069	0.040	0.028	0.021	0.016	0.012	0.010	0.010	0.008	0.007	0.008	0.007	0.006	0.005	0.005	0.005	0.004	0.004
18	0.083	0.046	0.030	0.025	0.022	0.020	0.018	0.013	0.012	0.009	0.010	0.009	0.008	0.008	0.008	0.007	0.006	0.006
19	0.070	0.032	0.021	0.020	0.016	0.011	0.013	0.009	0.008	0.006	0.006	0.004	0.004	0.004	0.004	0.004	0.005	0.004
Average	0.102	0.045	0.029	0.022	0.018	0.015	0.014	0.012	0.010	0.009	0.008	0.007	0.007	0.006	0.007	0.006	0.005	0.005
St. Dev.	0.092	0.032	0.018	0.013	0.012	0.011	0.013	0.015	0.010	0.010	0.009	0.007	0.007	0.007	0.007	0.008	0.006	0.007

Table 25: Time to return to pre-kneeling baseline values for standing task for the RGL muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.073	0.036	0.024	0.018	0.014	0.012	0.012	0.011	0.008	0.009	0.007	0.006	0.005	0.005	0.005	0.004	0.004	0.004
2	0.010	0.002	0.008	0.003	0.002	0.006	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.045	0.019	0.008	0.004	0.002	0.001	0.001	0.004	0.002	0.003	0.003	0.003	0.002	0.003	0.003	0.003	0.002	0.002
4	0.030	0.024	0.017	0.016	0.009	0.020	0.017	0.019	0.022	0.016	0.019	0.017	0.011	0.006	0.004	0.003	0.002	0.003
5	0.045	0.027	0.002	0.010	0.000	0.000	0.000	0.000	0.003	0.001	0.001	0.000	0.000	0.000	0.000	0.003	0.002	0.007
6	0.087	0.042	0.029	0.022	0.018	0.015	0.015	0.014	0.011	0.009	0.007	0.006	0.006	0.005	0.006	0.006	0.005	0.004
7	0.048	0.022	0.015	0.011	0.008	0.006	0.006	0.006	0.004	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.003	0.002
8	0.196	0.103	0.068	0.052	0.031	0.024	0.019	0.016	0.014	0.012	0.011	0.010	0.009	0.008	0.007	0.006	0.006	0.006
9	0.064	0.038	0.021	0.012	0.012	0.009	0.007	0.006	0.005	0.004	0.001	0.001	0.003	0.003	0.003	0.003	0.003	0.003
10	0.109	0.282	0.200	0.163	0.126	0.112	0.072	0.078	0.077	0.062	0.052	0.013	0.011	0.011	0.009	0.009	0.008	0.007
11	0.327	0.075	0.044	0.041	0.030	0.030	0.001	0.002	0.005	0.002	0.002	0.001	0.001	0.000	0.000	0.003	0.001	0.000
12	0.072	0.034	0.021	0.015	0.011	0.008	0.007	0.007	0.006	0.005	0.005	0.005	0.005	0.004	0.003	0.003	0.003	0.003
13	0.039	0.023	0.009	0.009	0.006	0.005	0.004	0.003	0.004	0.004	0.003	0.004	0.002	0.003	0.003	0.001	0.001	0.001
14																		
15	0.034	0.019	0.010	0.010	0.008	0.005	0.009	0.006	0.003	0.003	0.002	0.002	0.004	0.002	0.002	0.002	0.003	0.003
16	0.046	0.023	0.015	0.011	0.009	0.009	0.007	0.006	0.005	0.005	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003
17	0.056	0.073	0.027	0.018	0.021	0.015	0.009	0.006	0.005	0.004	0.004	0.003	0.004	0.003	0.003	0.003	0.003	0.002
18	0.135	0.039	0.021	0.011	0.008	0.008	0.005	0.007	0.005	0.008	0.007	0.007	0.006	0.005	0.005	0.005	0.005	0.004
19	0.036	0.017	0.009	0.008	0.006	0.007	0.006	0.007	0.006	0.006	0.005	0.004	0.006	0.006	0.006	0.005	0.005	0.005
Average	0.081	0.050	0.030	0.024	0.018	0.016	0.011	0.011	0.010	0.009	0.008	0.005	0.005	0.004	0.004	0.004	0.003	0.003
St. Dev.	0.075	0.063	0.045	0.037	0.028	0.025	0.016	0.017	0.017	0.014	0.012	0.004	0.003	0.003	0.002	0.002	0.002	0.002

Table 26: Time to return to pre-kneeling baseline values for sitting task for the RRA muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.005	0.008	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.003	0.002	0.001
2	0.020	0.004	0.003	0.003	0.003	0.002	0.001	0.001	0.001	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001
3	0.029	0.020	0.020	0.009	0.005	0.012	0.010	0.009	0.008	0.007	0.006	0.006	0.006	0.005	0.005	0.004	0.005	0.004
4	0.115	0.027	0.023	0.013	0.011	0.014	0.005	0.004	0.003	0.003	0.004	0.001	0.001	0.001	0.001	0.002	0.003	0.002
5	0.020	0.009	0.005	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
6	0.086	0.021	0.011	0.005	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.312	0.116	0.057	0.029	0.007	0.001	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002
8	0.020	0.008	0.005	0.003	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
9	0.031	0.000	0.003	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.002	0.003	0.002	0.002	0.002	0.002	0.002	0.002
10	0.008	0.002	0.005	0.005	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
11	0.421	0.139	0.017	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.000
12	0.112	0.058	0.049	0.040	0.032	0.024	0.021	0.020	0.018	0.017	0.014	0.013	0.013	0.012	0.011	0.010	0.010	0.009
13	0.020	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14																		
15	0.047	0.019	0.011	0.007	0.005	0.004	0.003	0.003	0.002	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001
16	0.034	0.024	0.008	0.005	0.005	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
17	0.001	0.000	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000
18	0.008	0.003	0.000	0.001	0.009	0.010	0.010	0.009	0.009	0.008	0.007	0.007	0.006	0.006	0.006	0.005	0.005	0.005
19	0.030	0.048	0.041	0.027	0.010	0.018	0.002	0.003	0.002	0.001	0.001	0.001	0.001	0.007	0.015	0.001	0.000	0.001
Average	0.073	0.028	0.015	0.009	0.006	0.006	0.004	0.004	0.003	0.003	0.003	0.002	0.002	0.003	0.003	0.002	0.002	0.002
St. Dev.	0.113	0.040	0.017	0.011	0.007	0.007	0.005	0.005	0.004	0.004	0.003	0.003	0.003	0.003	0.004	0.003	0.002	0.002

Table 27: Time to return to pre-kneeling baseline values for walking task for the RRA muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.045	0.029	0.012	0.009	0.006	0.006	0.004	0.003	0.004	0.004	0.003	0.002	0.002	0.002	0.002	0.001	0.005	0.004
2	0.079	0.039	0.026	0.020	0.016	0.013	0.011	0.010	0.009	0.008	0.007	0.006	0.006	0.006	0.005	0.005	0.005	0.004
3	0.074	0.040	0.031	0.026	0.021	0.020	0.017	0.019	0.018	0.017	0.015	0.014	0.012	0.012	0.011	0.010	0.010	0.009
4	0.075	0.011	0.005	0.007	0.004	0.004	0.003	0.003	0.003	0.002	0.001	0.002	0.001	0.000	0.002	0.000	0.000	0.001
5	0.030	0.016	0.026	0.011	0.009	0.006	0.005	0.004	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.001	0.002	0.001
6	0.172	0.045	0.016	0.011	0.003	0.004	0.004	0.003	0.005	0.005	0.003	0.005	0.005	0.007	0.003	0.003	0.003	0.002
7	0.044	0.011	0.008	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.000
8	0.211	0.106	0.070	0.053	0.040	0.035	0.030	0.026	0.024	0.021	0.020	0.018	0.017	0.016	0.015	0.014	0.013	0.012
9	0.023	0.005	0.003	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.001	0.001	0.001
10	0.043	0.016	0.005	0.006	0.008	0.002	0.001	0.001	0.000	0.000	0.001	0.001	0.001	0.001	0.000	0.000	0.001	0.001
11	0.051	0.041	0.029	0.039	0.033	0.020	0.012	0.002	0.000	0.000	0.002	0.001	0.001	0.002	0.002	0.001	0.002	0.002
12	0.022	0.011	0.007	0.007	0.004	0.005	0.005	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
13	0.056	0.030	0.019	0.004	0.001	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.002	0.000	0.001	0.001
14																		
15	0.073	0.118	0.059	0.013	0.006	0.003	0.003	0.002	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001
16	0.018	0.011	0.006	0.006	0.005	0.004	0.003	0.003	0.003	0.004	0.003	0.002	0.002	0.002	0.002	0.001	0.001	0.002
17	0.107	0.067	0.024	0.009	0.005	0.002	0.003	0.003	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002
18	0.022	0.007	0.004	0.003	0.003	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
19	0.089	0.030	0.012	0.008	0.010	0.005	0.027	0.008	0.003	0.002	0.003	0.002	0.003	0.010	0.006	0.011	0.010	0.009
Average	0.068	0.035	0.020	0.013	0.010	0.007	0.007	0.005	0.005	0.004	0.004	0.004	0.003	0.004	0.003	0.003	0.003	0.003
St. Dev.	0.052	0.032	0.019	0.014	0.011	0.009	0.009	0.007	0.006	0.006	0.005	0.005	0.004	0.005	0.004	0.004	0.004	0.003

Table 28: Time to return to pre-kneeling baseline values for standing task for the RRA muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.037	0.015	0.012	0.007	0.004	0.005	0.006	0.005	0.004	0.003	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001
2	0.005	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000
3	0.095	0.043	0.026	0.021	0.016	0.012	0.010	0.008	0.008	0.007	0.006	0.006	0.005	0.005	0.004	0.004	0.004	0.004
4	0.023	0.039	0.034	0.039	0.068	0.029	0.033	0.014	0.024	0.016	0.013	0.002	0.001	0.001	0.005	0.006	0.007	0.006
5	0.033	0.026	0.006	0.005	0.003	0.003	0.002	0.002	0.002	0.004	0.003	0.002	0.001	0.002	0.002	0.004	0.003	0.004
6	0.005	0.001	0.001	0.007	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000
7	0.161	0.032	0.004	0.005	0.017	0.019	0.023	0.022	0.015	0.018	0.018	0.016	0.013	0.015	0.015	0.014	0.014	0.013
8	0.019	0.009	0.006	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
9	0.030	0.007	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
10	0.007	0.006	0.002	0.002	0.002	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.002
11	0.037	0.009	0.003	0.007	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.001	0.000	0.000	0.001	0.000
12	0.142	0.061	0.048	0.038	0.032	0.027	0.023	0.020	0.018	0.016	0.015	0.013	0.013	0.012	0.011	0.010	0.009	0.009
13	0.028	0.015	0.005	0.004	0.002	0.002	0.002	0.001	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001
14																		
15	0.006	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.016	0.010	0.006	0.004	0.003	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002
17	0.167	0.095	0.048	0.017	0.039	0.020	0.012	0.006	0.004	0.002	0.001	0.001	0.003	0.000	0.000	0.000	0.001	0.002
18	0.067	0.014	0.021	0.002	0.003	0.001	0.002	0.005	0.003	0.005	0.000	0.002	0.001	0.003	0.001	0.002	0.004	0.004
19	0.083	0.041	0.028	0.021	0.017	0.014	0.012	0.010	0.009	0.008	0.008	0.007	0.006	0.006	0.006	0.005	0.005	0.005
Average	0.053	0.024	0.014	0.010	0.012	0.008	0.007	0.006	0.005	0.005	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003
St. Dev.	0.054	0.025	0.016	0.012	0.018	0.010	0.010	0.007	0.007	0.006	0.006	0.005	0.004	0.004	0.004	0.004	0.004	0.004

Table 29: Time to return to pre-kneeling baseline values for sitting task for the LRA muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.061	0.010	0.009	0.009	0.008	0.007	0.007	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.001
2	0.030	0.016	0.010	0.008	0.006	0.005	0.004	0.004	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002
3	0.024	0.060	0.009	0.010	0.010	0.011	0.010	0.010	0.009	0.008	0.007	0.006	0.006	0.006	0.005	0.005	0.005	0.005
4	0.155	0.044	0.026	0.021	0.019	0.018	0.007	0.007	0.006	0.004	0.006	0.002	0.002	0.002	0.002	0.004	0.003	0.003
5	0.016	0.004	0.002	0.000	0.001	0.001	0.000	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.023	0.006	0.002	0.001	0.001	0.001	0.001	0.000	0.001	0.001	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000
7	0.189	0.073	0.036	0.022	0.010	0.005	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000
8	0.019	0.010	0.006	0.003	0.003	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.037	0.007	0.011	0.011	0.009	0.010	0.008	0.007	0.007	0.006	0.006	0.005	0.005	0.005	0.004	0.004	0.004	0.003
10	0.275	0.164	0.114	0.091	0.074	0.061	0.052	0.046	0.042	0.037	0.034	0.031	0.029	0.027	0.025	0.023	0.022	0.021
11	0.250	0.070	0.023	0.006	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000
12	0.107	0.061	0.043	0.036	0.028	0.023	0.020	0.019	0.017	0.015	0.013	0.012	0.012	0.011	0.010	0.010	0.009	0.008
13	0.015	0.000	0.001	0.002	0.002	0.003	0.003	0.002	0.002	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
14																		
15	0.025	0.016	0.008	0.005	0.003	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.010	0.001	0.003
16	0.020	0.009	0.004	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.000	0.001
17	0.018	0.009	0.008	0.007	0.006	0.004	0.004	0.003	0.002	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.001
18	0.009	0.002	0.002	0.001	0.008	0.009	0.009	0.008	0.007	0.007	0.006	0.006	0.005	0.005	0.005	0.004	0.004	0.004
19	0.012	0.032	0.021	0.019	0.004	0.008	0.005	0.001	0.002	0.003	0.003	0.002	0.001	0.004	0.011	0.000	0.001	0.001
Average	0.071	0.033	0.019	0.014	0.011	0.010	0.008	0.007	0.006	0.005	0.005	0.004	0.004	0.004	0.004	0.004	0.003	0.003
St. Dev.	0.086	0.041	0.027	0.021	0.017	0.014	0.012	0.011	0.010	0.009	0.008	0.007	0.007	0.006	0.006	0.006	0.005	0.005

Table 30: Time to return to pre-kneeling baseline values for walking task for the LRA muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.043	0.038	0.009	0.006	0.002	0.003	0.002	0.002	0.004	0.003	0.002	0.001	0.002	0.001	0.002	0.002	0.005	0.005
2	0.068	0.036	0.028	0.019	0.015	0.011	0.011	0.008	0.009	0.008	0.008	0.006	0.006	0.005	0.006	0.004	0.006	0.005
3	0.063	0.038	0.034	0.029	0.022	0.021	0.018	0.017	0.016	0.014	0.014	0.012	0.010	0.010	0.010	0.009	0.008	0.008
4	0.061	0.025	0.004	0.007	0.009	0.010	0.008	0.009	0.008	0.007	0.007	0.006	0.006	0.005	0.005	0.005	0.005	0.004
5	0.030	0.016	0.001	0.005	0.005	0.005	0.004	0.003	0.004	0.003	0.003	0.002	0.003	0.002	0.002	0.002	0.002	0.002
6	0.031	0.046	0.035	0.033	0.030	0.027	0.025	0.023	0.021	0.020	0.018	0.017	0.016	0.015	0.014	0.013	0.012	0.012
7	0.163	0.101	0.072	0.057	0.046	0.040	0.034	0.030	0.026	0.024	0.022	0.020	0.018	0.017	0.016	0.015	0.014	0.013
8	0.044	0.014	0.010	0.007	0.008	0.005	0.005	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001
9	0.002	0.002	0.004	0.003	0.004	0.002	0.002	0.002	0.001	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001
10	0.112	0.033	0.032	0.016	0.016	0.004	0.002	0.001	0.002	0.002	0.001	0.000	0.001	0.000	0.001	0.001	0.000	0.000
11	0.052	0.013	0.042	0.046	0.013	0.010	0.004	0.003	0.001	0.002	0.001	0.002	0.000	0.001	0.001	0.001	0.000	0.001
12	0.041	0.015	0.009	0.005	0.005	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.001
13	0.006	0.005	0.002	0.006	0.007	0.008	0.007	0.006	0.005	0.005	0.005	0.004	0.004	0.004	0.004	0.003	0.003	0.003
14																		
15	0.083	0.115	0.053	0.017	0.011	0.008	0.006	0.006	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.001	0.002
16	0.017	0.009	0.005	0.004	0.004	0.003	0.002	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001
17	0.107	0.049	0.029	0.009	0.004	0.002	0.004	0.004	0.003	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.002
18	0.022	0.009	0.006	0.003	0.003	0.003	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
19	0.075	0.035	0.013	0.010	0.013	0.004	0.021	0.010	0.004	0.002	0.003	0.002	0.002	0.005	0.002	0.006	0.004	0.004
Average	0.057	0.033	0.021	0.016	0.012	0.009	0.009	0.008	0.006	0.006	0.005	0.005	0.004	0.004	0.004	0.004	0.004	0.004
St. Dev.	0.041	0.031	0.020	0.016	0.011	0.010	0.009	0.008	0.007	0.007	0.006	0.006	0.005	0.005	0.005	0.004	0.004	0.004

Table 31: Time to return to pre-kneeling baseline values for standing task for the LRA muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.013	0.005	0.001	0.010	0.011	0.004	0.001	0.000	0.004	0.003	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
2	0.132	0.052	0.032	0.019	0.014	0.012	0.013	0.010	0.007	0.006	0.005	0.008	0.009	0.008	0.008	0.008	0.007	0.007
3	0.008	0.006	0.006	0.003	0.004	0.005	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
4	0.102	0.013	0.011	0.011	0.002	0.025	0.015	0.011	0.011	0.013	0.010	0.002	0.005	0.001	0.002	0.003	0.004	0.002
5	0.023	0.018	0.001	0.001	0.001	0.000	0.001	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.001
6	0.016	0.006	0.002	0.001	0.001	0.001	0.001	0.000	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.174	0.038	0.003	0.002	0.011	0.016	0.019	0.017	0.012	0.013	0.014	0.012	0.011	0.012	0.011	0.011	0.010	0.010
8	0.020	0.012	0.008	0.006	0.005	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
9	0.036	0.010	0.005	0.003	0.001	0.001	0.000	0.001	0.001	0.000	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000
10	0.030	0.007	0.012	0.009	0.011	0.010	0.008	0.006	0.006	0.007	0.006	0.006	0.005	0.005	0.005	0.004	0.004	0.004
11	0.018	0.008	0.002	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.000	0.000	0.000	0.000
12	0.088	0.032	0.032	0.028	0.023	0.019	0.017	0.015	0.013	0.012	0.011	0.010	0.009	0.008	0.008	0.008	0.007	0.007
13	0.031	0.014	0.004	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.000	0.001
14																		
15	0.003	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000
16	0.002	0.003	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000
17	0.081	0.079	0.031	0.007	0.030	0.012	0.006	0.004	0.003	0.002	0.001	0.001	0.002	0.001	0.001	0.001	0.002	0.002
18	0.066	0.008	0.014	0.003	0.001	0.003	0.005	0.005	0.003	0.005	0.002	0.002	0.002	0.003	0.001	0.003	0.003	0.003
19	0.040	0.005	0.008	0.004	0.003	0.003	0.002	0.001	0.001	0.002	0.001	0.003	0.002	0.001	0.001	0.001	0.001	0.001
Average	0.049	0.017	0.010	0.006	0.007	0.007	0.006	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003
St. Dev.	0.048	0.020	0.011	0.007	0.008	0.007	0.006	0.005	0.004	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.003

Table 32: Time to return to pre-kneeling baseline values for sitting task for the RES muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.494	0.206	0.144	0.111	0.091	0.076	0.067	0.058	0.050	0.044	0.038	0.036	0.033	0.027	0.027	0.022	0.022	0.022
2	1.239	0.633	0.475	0.362	0.290	0.228	0.205	0.181	0.161	0.145	0.132	0.121	0.111	0.103	0.097	0.090	0.085	0.081
3	0.044	0.021	0.031	0.027	0.027	0.023	0.020	0.013	0.014	0.013	0.011	0.011	0.008	0.010	0.009	0.008	0.008	0.007
4	0.146	0.078	0.051	0.039	0.019	0.015	0.020	0.018	0.017	0.015	0.013	0.012	0.012	0.011	0.011	0.010	0.007	0.005
5	0.055	0.031	0.030	0.024	0.016	0.014	0.012	0.012	0.011	0.010	0.009	0.008	0.008	0.007	0.007	0.006	0.006	0.004
6	0.103	0.058	0.038	0.030	0.024	0.021	0.018	0.015	0.013	0.012	0.012	0.011	0.010	0.009	0.008	0.008	0.007	0.007
7	0.062	0.006	0.002	0.004	0.008	0.003	0.006	0.005	0.006	0.034	0.000	0.001	0.003	0.003	0.003	0.002	0.002	0.001
8	0.016	0.005	0.003	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.118	0.058	0.049	0.039	0.032	0.028	0.024	0.021	0.019	0.017	0.015	0.014	0.013	0.012	0.011	0.010	0.010	0.009
10	0.271	0.197	0.136	0.101	0.080	0.067	0.057	0.050	0.045	0.040	0.036	0.033	0.030	0.028	0.026	0.024	0.023	0.022
11	0.250	0.049	0.020	0.088	0.077	0.093	0.080	0.072	0.059	0.048	0.050	0.045	0.042	0.038	0.033	0.033	0.032	0.027
12	0.051	0.083	0.008	0.060	0.052	0.046	0.040	0.041	0.037	0.035	0.029	0.027	0.026	0.025	0.023	0.021	0.020	0.019
13	0.268	0.135	0.094	0.073	0.058	0.049	0.042	0.036	0.033	0.029	0.026	0.024	0.022	0.021	0.020	0.018	0.015	0.015
14																		
15	0.108	0.055	0.038	0.025	0.023	0.018	0.014	0.015	0.014	0.013	0.012	0.009	0.009	0.009	0.009	0.008	0.007	0.006
16	0.184	0.083	0.023	0.000	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.002	0.002	0.001	0.002	0.002	0.002
17	0.204	0.097	0.067	0.049	0.039	0.033	0.030	0.025	0.020	0.019	0.020	0.018	0.016	0.015	0.014	0.013	0.011	0.010
18	0.089	0.038	0.019	0.025	0.023	0.019	0.017	0.015	0.013	0.012	0.011	0.010	0.009	0.008	0.008	0.007	0.007	0.007
19	0.007	0.006	0.095	0.055	0.081	0.009	0.005	0.004	0.005	0.001	0.003	0.003	0.006	0.002	0.003	0.002	0.002	0.003
Average	0.206	0.102	0.073	0.062	0.053	0.041	0.037	0.033	0.029	0.027	0.023	0.021	0.020	0.018	0.017	0.016	0.015	0.014
St. Dev.	0.284	0.145	0.109	0.082	0.066	0.053	0.048	0.042	0.037	0.033	0.030	0.028	0.026	0.024	0.022	0.021	0.020	0.018

Table 33: Time to return to pre-kneeling baseline values for walking task for the RES muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.039	0.029	0.024	0.018	0.014	0.012	0.012	0.011	0.008	0.008	0.008	0.007	0.007	0.006	0.006	0.007	0.012	0.011
2	0.196	0.103	0.072	0.057	0.043	0.038	0.032	0.028	0.025	0.023	0.021	0.019	0.018	0.016	0.014	0.014	0.012	0.012
3	0.006	0.006	0.005	0.002	0.002	0.002	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
4	0.014	0.011	0.008	0.004	0.003	0.004	0.003	0.003	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.001
5	0.038	0.017	0.023	0.010	0.005	0.005	0.002	0.002	0.002	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001
6	0.038	0.026	0.016	0.015	0.011	0.010	0.005	0.005	0.005	0.003	0.005	0.004	0.004	0.004	0.003	0.004	0.004	0.004
7	0.078	0.030	0.018	0.013	0.010	0.009	0.007	0.008	0.005	0.005	0.005	0.004	0.004	0.003	0.003	0.004	0.002	0.003
8	0.064	0.033	0.025	0.018	0.018	0.011	0.009	0.008	0.007	0.006	0.005	0.005	0.005	0.004	0.004	0.004	0.004	0.003
9	0.009	0.005	0.000	0.002	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
10	0.003	0.008	0.006	0.004	0.004	0.002	0.004	0.003	0.003	0.004	0.003	0.003	0.003	0.001	0.000	0.002	0.001	0.001
11	0.019	0.005	0.005	0.013	0.000	0.002	0.006	0.006	0.004	0.003	0.004	0.005	0.005	0.001	0.003	0.003	0.004	0.003
12	0.005	0.006	0.004	0.005	0.004	0.001	0.003	0.005	0.001	0.000	0.001	0.002	0.002	0.002	0.001	0.002	0.001	0.001
13	0.120	0.061	0.041	0.031	0.027	0.025	0.021	0.018	0.014	0.013	0.012	0.011	0.010	0.010	0.009	0.009	0.009	0.008
14																		
15	0.028	0.001	0.013	0.014	0.005	0.010	0.010	0.003	0.008	0.010	0.009	0.006	0.007	0.007	0.007	0.007	0.006	0.005
16	0.011	0.002	0.002	0.002	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.001	0.000
17	0.060	0.020	0.045	0.036	0.031	0.024	0.021	0.020	0.018	0.015	0.014	0.013	0.012	0.011	0.011	0.010	0.008	0.008
18	0.014	0.011	0.000	0.004	0.003	0.003	0.004	0.004	0.002	0.002	0.002	0.001	0.000	0.002	0.001	0.001	0.001	0.001
19	0.023	0.013	0.003	0.007	0.006	0.002	0.024	0.012	0.005	0.001	0.002	0.002	0.002	0.001	0.001	0.002	0.002	0.000
Average	0.043	0.022	0.017	0.014	0.011	0.009	0.009	0.008	0.006	0.005	0.005	0.005	0.005	0.004	0.004	0.004	0.004	0.004
St. Dev.	0.049	0.025	0.019	0.015	0.012	0.010	0.009	0.007	0.007	0.006	0.006	0.005	0.005	0.004	0.004	0.004	0.004	0.004

Table 34: Time to return to pre-kneeling baseline values for standing task for the RES muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.222	0.132	0.084	0.070	0.058	0.049	0.041	0.035	0.028	0.027	0.027	0.022	0.022	0.020	0.019	0.016	0.013	0.015
2	0.658	0.326	0.252	0.105	0.147	0.115	0.038	0.083	0.088	0.077	0.074	0.057	0.062	0.058	0.050	0.045	0.041	0.041
3	0.303	0.124	0.109	0.080	0.065	0.055	0.047	0.042	0.035	0.028	0.029	0.025	0.026	0.024	0.021	0.020	0.019	0.018
4	0.107	0.069	0.045	0.025	0.026	0.016	0.014	0.012	0.008	0.007	0.005	0.007	0.004	0.007	0.006	0.007	0.007	0.006
5	0.188	0.122	0.086	0.064	0.052	0.043	0.028	0.033	0.029	0.026	0.024	0.022	0.020	0.019	0.018	0.016	0.015	0.015
6	0.081	0.036	0.025	0.020	0.017	0.014	0.014	0.014	0.013	0.012	0.011	0.009	0.008	0.006	0.005	0.005	0.005	0.005
7	0.075	0.026	0.004	0.006	0.013	0.020	0.018	0.010	0.007	0.010	0.014	0.007	0.006	0.010	0.011	0.012	0.012	0.011
8	0.008	0.000	0.002	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000
9	0.049	0.033	0.029	0.020	0.018	0.018	0.014	0.010	0.009	0.008	0.009	0.008	0.005	0.005	0.006	0.007	0.006	0.006
10	0.256	0.133	0.086	0.061	0.055	0.047	0.038	0.033	0.030	0.028	0.024	0.024	0.021	0.020	0.020	0.015	0.015	0.016
11	0.153	0.076	0.053	0.042	0.033	0.023	0.021	0.019	0.008	0.012	0.014	0.013	0.011	0.010	0.007	0.010	0.010	0.009
12	0.046	0.005	0.004	0.005	0.008	0.003	0.003	0.003	0.004	0.004	0.003	0.006	0.006	0.006	0.005	0.004	0.004	0.004
13	0.068	0.029	0.009	0.010	0.006	0.005	0.004	0.003	0.003	0.003	0.002	0.003	0.011	0.003	0.002	0.002	0.001	0.003
14																		
15	0.361	0.177	0.121	0.090	0.071	0.061	0.051	0.043	0.039	0.035	0.033	0.030	0.028	0.026	0.024	0.022	0.021	0.020
16	0.139	0.063	0.057	0.044	0.038	0.031	0.027	0.024	0.021	0.019	0.017	0.016	0.014	0.013	0.012	0.012	0.011	0.010
17	0.145	0.056	0.054	0.042	0.018	0.022	0.030	0.030	0.027	0.025	0.021	0.021	0.018	0.018	0.017	0.016	0.013	0.014
18	0.042	0.002	0.017	0.004	0.003	0.003	0.001	0.003	0.001	0.004	0.002	0.001	0.001	0.002	0.001	0.003	0.003	0.002
19	0.036	0.007	0.002	0.000	0.006	0.003	0.001	0.005	0.000	0.003	0.002	0.004	0.004	0.003	0.002	0.001	0.000	0.000
Average	**0.163**	**0.079**	**0.058**	**0.038**	**0.035**	**0.029**	**0.022**	**0.022**	**0.020**	**0.018**	**0.017**	**0.015**	**0.015**	**0.014**	**0.013**	**0.012**	**0.011**	**0.011**
St. Dev.	**0.158**	**0.081**	**0.062**	**0.033**	**0.036**	**0.029**	**0.017**	**0.021**	**0.021**	**0.018**	**0.018**	**0.014**	**0.015**	**0.014**	**0.012**	**0.011**	**0.010**	**0.010**

Table 35: Time to return to pre-kneeling baseline values for sitting task for the LES muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.186	0.050	0.041	0.037	0.032	0.027	0.023	0.019	0.016	0.014	0.011	0.007	0.008	0.003	0.008	0.005	0.005	0.006
2	0.799	0.399	0.272	0.215	0.173	0.137	0.123	0.109	0.096	0.087	0.079	0.072	0.067	0.062	0.058	0.054	0.051	0.048
3	0.286	0.130	0.097	0.070	0.063	0.054	0.046	0.034	0.036	0.032	0.028	0.027	0.025	0.023	0.021	0.020	0.018	0.017
4	0.544	0.276	0.179	0.139	0.111	0.081	0.081	0.068	0.062	0.055	0.048	0.044	0.042	0.040	0.038	0.035	0.032	0.031
5	0.082	0.026	0.008	0.005	0.009	0.008	0.008	0.006	0.005	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.003
6	0.051	0.040	0.027	0.022	0.018	0.018	0.015	0.013	0.012	0.011	0.010	0.009	0.008	0.008	0.007	0.007	0.006	0.006
7	0.103	0.048	0.028	0.031	0.030	0.017	0.018	0.018	0.015	0.014	0.013	0.013	0.011	0.011	0.011	0.010	0.010	0.009
8	0.024	0.009	0.003	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.000
9	0.073	0.042	0.035	0.030	0.025	0.023	0.020	0.018	0.016	0.015	0.014	0.013	0.012	0.011	0.010	0.009	0.009	0.008
10	0.091	0.062	0.046	0.034	0.027	0.024	0.020	0.017	0.016	0.014	0.013	0.012	0.011	0.011	0.010	0.009	0.009	0.008
11	0.950	0.501	0.361	0.278	0.227	0.191	0.165	0.145	0.130	0.117	0.106	0.098	0.090	0.084	0.078	0.073	0.069	0.065
12	0.340	0.194	0.135	0.104	0.085	0.066	0.057	0.053	0.048	0.044	0.038	0.033	0.033	0.031	0.029	0.028	0.026	0.024
13	0.068	0.038	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14																		
15	0.170	0.089	0.062	0.044	0.034	0.019	0.021	0.023	0.021	0.019	0.018	0.015	0.014	0.014	0.013	0.012	0.010	0.010
16	0.143	0.136	0.032	0.001	0.009	0.009	0.008	0.007	0.007	0.006	0.005	0.005	0.005	0.004	0.002	0.004	0.003	0.003
17	0.012	0.013	0.007	0.006	0.005	0.005	0.005	0.004	0.002	0.003	0.003	0.003	0.002	0.003	0.002	0.002	0.001	0.001
18	0.111	0.058	0.038	0.030	0.031	0.028	0.025	0.021	0.019	0.016	0.016	0.015	0.014	0.013	0.012	0.009	0.010	0.010
19	0.020	0.014	0.012	0.017	0.009	0.012	0.010	0.008	0.009	0.007	0.006	0.006	0.003	0.003	0.003	0.002	0.002	0.001
Average	**0.225**	**0.118**	**0.077**	**0.059**	**0.050**	**0.040**	**0.036**	**0.031**	**0.028**	**0.025**	**0.023**	**0.021**	**0.019**	**0.018**	**0.017**	**0.016**	**0.015**	**0.014**
St. Dev.	**0.272**	**0.140**	**0.100**	**0.078**	**0.063**	**0.051**	**0.045**	**0.039**	**0.035**	**0.032**	**0.029**	**0.026**	**0.025**	**0.023**	**0.021**	**0.020**	**0.019**	**0.018**

Table 36: Time to return to pre-kneeling baseline values for walking task for the LES muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.076	0.034	0.022	0.010	0.006	0.007	0.006	0.005	0.006	0.004	0.004	0.003	0.005	0.004	0.003	0.002	0.003	0.003
2	0.106	0.054	0.035	0.027	0.018	0.019	0.016	0.014	0.014	0.012	0.010	0.009	0.009	0.009	0.007	0.006	0.006	0.007
3	0.048	0.007	0.009	0.006	0.003	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.001	0.001
4	0.031	0.018	0.016	0.010	0.004	0.006	0.005	0.005	0.004	0.004	0.002	0.003	0.003	0.002	0.002	0.002	0.001	0.002
5	0.052	0.023	0.029	0.010	0.008	0.009	0.005	0.003	0.003	0.004	0.002	0.003	0.002	0.002	0.002	0.002	0.002	0.002
6	0.033	0.029	0.020	0.017	0.013	0.012	0.009	0.007	0.007	0.005	0.006	0.006	0.005	0.005	0.004	0.005	0.005	0.004
7	0.069	0.027	0.021	0.013	0.011	0.008	0.008	0.006	0.005	0.005	0.005	0.004	0.004	0.005	0.003	0.003	0.003	0.002
8	0.024	0.019	0.012	0.009	0.009	0.006	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.001	0.001
9	0.036	0.022	0.010	0.008	0.006	0.004	0.003	0.002	0.003	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000
10	0.021	0.019	0.012	0.006	0.008	0.006	0.007	0.006	0.004	0.005	0.005	0.005	0.004	0.004	0.001	0.004	0.003	0.003
11	0.148	0.078	0.036	0.024	0.027	0.025	0.025	0.021	0.021	0.019	0.017	0.016	0.014	0.013	0.013	0.013	0.013	0.012
12	0.324	0.174	0.118	0.093	0.073	0.061	0.053	0.047	0.039	0.037	0.033	0.030	0.029	0.026	0.024	0.023	0.022	0.020
13	0.208	0.093	0.070	0.049	0.040	0.035	0.030	0.025	0.021	0.020	0.016	0.017	0.013	0.014	0.014	0.012	0.013	0.011
14																		
15	0.113	0.033	0.039	0.028	0.024	0.020	0.020	0.017	0.016	0.015	0.013	0.013	0.013	0.011	0.011	0.010	0.008	0.009
16	0.046	0.018	0.008	0.009	0.010	0.006	0.004	0.005	0.004	0.005	0.005	0.004	0.003	0.003	0.002	0.002	0.002	0.003
17	0.154	0.002	0.051	0.038	0.036	0.034	0.033	0.028	0.025	0.022	0.021	0.019	0.018	0.016	0.015	0.014	0.013	0.011
18	0.005	0.001	0.006	0.003	0.003	0.003	0.000	0.000	0.001	0.002	0.001	0.001	0.000	0.001	0.001	0.000	0.001	0.000
19	0.051	0.041	0.027	0.018	0.016	0.013	0.007	0.009	0.010	0.007	0.007	0.006	0.007	0.008	0.006	0.005	0.007	0.004
Average	0.086	0.038	0.030	0.021	0.018	0.015	0.013	0.011	0.010	0.010	0.008	0.008	0.007	0.007	0.006	0.006	0.006	0.005
St. Dev.	0.080	0.041	0.027	0.022	0.018	0.015	0.014	0.012	0.010	0.009	0.009	0.008	0.007	0.007	0.007	0.006	0.006	0.005

Table 37: Time to return to pre-kneeling baseline values for standing task for the LES muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.071	0.034	0.023	0.016	0.015	0.013	0.011	0.008	0.009	0.007	0.008	0.006	0.005	0.006	0.006	0.005	0.005	0.005
2	0.488	0.285	0.200	0.128	0.122	0.094	0.069	0.064	0.067	0.061	0.055	0.049	0.047	0.044	0.039	0.037	0.036	0.033
3	0.112	0.003	0.033	0.020	0.025	0.020	0.017	0.014	0.001	0.002	0.002	0.008	0.011	0.011	0.009	0.007	0.006	0.006
4	0.402	0.231	0.154	0.101	0.071	0.066	0.053	0.044	0.035	0.032	0.023	0.036	0.023	0.027	0.029	0.028	0.028	0.025
5	0.096	0.021	0.010	0.007	0.005	0.005	0.009	0.005	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002
6	0.117	0.056	0.036	0.030	0.024	0.021	0.020	0.019	0.017	0.015	0.014	0.012	0.011	0.009	0.008	0.007	0.007	0.007
7	0.007	0.021	0.024	0.022	0.025	0.027	0.017	0.006	0.011	0.012	0.015	0.012	0.011	0.012	0.012	0.013	0.012	0.012
8	0.030	0.017	0.012	0.009	0.008	0.006	0.005	0.004	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002
9	0.142	0.067	0.030	0.015	0.018	0.018	0.021	0.014	0.010	0.010	0.014	0.009	0.012	0.012	0.011	0.011	0.009	0.010
10	0.246	0.108	0.083	0.049	0.052	0.046	0.038	0.033	0.030	0.028	0.025	0.024	0.021	0.021	0.020	0.017	0.016	0.016
11	0.300	0.160	0.108	0.083	0.070	0.044	0.044	0.038	0.020	0.020	0.021	0.021	0.021	0.022	0.023	0.016	0.016	0.017
12	0.399	0.175	0.139	0.110	0.091	0.076	0.065	0.056	0.050	0.046	0.041	0.038	0.035	0.032	0.031	0.029	0.027	0.025
13	0.112	0.056	0.036	0.032	0.026	0.021	0.012	0.007	0.008	0.007	0.005	0.005	0.016	0.014	0.005	0.001	0.001	0.002
14																		
15	0.200	0.108	0.075	0.053	0.041	0.038	0.029	0.025	0.025	0.021	0.021	0.018	0.015	0.017	0.016	0.014	0.013	0.013
16	0.119	0.021	0.034	0.034	0.028	0.023	0.019	0.017	0.014	0.013	0.013	0.012	0.012	0.011	0.010	0.009	0.009	0.008
17	0.171	0.050	0.082	0.013	0.012	0.007	0.029	0.046	0.042	0.036	0.032	0.032	0.024	0.026	0.025	0.023	0.022	0.021
18	0.023	0.063	0.017	0.030	0.024	0.022	0.017	0.016	0.015	0.009	0.013	0.010	0.008	0.009	0.007	0.010	0.011	0.010
19	0.066	0.026	0.014	0.015	0.009	0.007	0.008	0.008	0.007	0.006	0.005	0.006	0.008	0.005	0.004	0.004	0.004	0.004
Average	0.172	0.084	0.062	0.043	0.037	0.031	0.027	0.024	0.020	0.018	0.017	0.017	0.016	0.016	0.014	0.013	0.013	0.012
St. Dev.	0.141	0.080	0.056	0.037	0.032	0.026	0.020	0.019	0.018	0.016	0.014	0.014	0.011	0.011	0.011	0.010	0.010	0.009

Table 38: Time to return to pre-kneeling baseline values for sitting task for the RVM muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.089	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.439	0.220	0.147	0.110	0.088	0.073	0.063	0.055	0.049	0.044	0.040	0.037	0.034	0.032	0.029	0.028	0.026	0.025
3	0.100	0.108	0.001	0.028	0.001	0.010	0.011	0.010	0.010	0.009	0.009	0.008	0.008	0.007	0.007	0.007	0.005	0.006
4	0.026	0.008	0.005	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.001	0.001	0.001	0.001
5	0.442	0.219	0.143	0.111	0.089	0.074	0.063	0.055	0.049	0.044	0.040	0.037	0.034	0.032	0.030	0.028	0.026	0.025
6	0.004	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001
7	0.296	0.095	0.070	0.039	0.019	0.009	0.005	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.002
8	0.049	0.001	0.005	0.009	0.009	0.010	0.009	0.009	0.009	0.008	0.008	0.007	0.007	0.006	0.006	0.006	0.005	0.005
9	0.010	0.009	0.006	0.006	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001
10	0.107	0.003	0.008	0.010	0.008	0.007	0.006	0.006	0.005	0.005	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003
11	0.092	0.075	0.032	0.011	0.007	0.005	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001
12	0.097	0.048	0.042	0.033	0.029	0.021	0.019	0.020	0.018	0.017	0.012	0.013	0.013	0.012	0.011	0.010	0.010	0.009
13	0.040	0.024	0.015	0.013	0.010	0.008	0.008	0.007	0.006	0.005	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.003
14																		
15	0.016	0.005	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
16	0.014	0.005	0.007	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.003	0.001	0.001	0.001
17	0.033	0.012	0.006	0.005	0.003	0.002	0.002	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
18	0.014	0.005	0.006	0.011	0.015	0.015	0.015	0.015	0.014	0.014	0.013	0.011	0.011	0.010	0.009	0.009	0.008	0.008
19	0.358	0.163	0.114	0.082	0.071	0.062	0.053	0.047	0.042	0.038	0.035	0.032	0.030	0.028	0.026	0.024	0.023	0.022
Average	0.124	0.056	0.034	0.026	0.020	0.017	0.015	0.013	0.012	0.011	0.010	0.009	0.009	0.008	0.008	0.007	0.007	0.006
St. Dev.	0.150	0.075	0.050	0.036	0.030	0.025	0.021	0.019	0.017	0.015	0.014	0.013	0.012	0.011	0.010	0.009	0.009	0.008

Table 39: Time to return to pre-kneeling baseline values for walking task for the RVM muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1																		
2	0.032	0.012	0.008	0.006	0.006	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
3	0.063	0.032	0.014	0.014	0.012	0.008	0.007	0.002	0.004	0.003	0.002	0.002	0.002	0.001	0.000	0.001	0.001	0.001
4	0.056	0.024	0.015	0.008	0.006	0.006	0.005	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.003	0.003
5	0.011	0.012	0.008	0.004	0.003	0.006	0.003	0.002	0.003	0.002	0.002	0.001	0.003	0.001	0.001	0.001	0.002	0.001
6	0.104	0.031	0.016	0.012	0.009	0.035	0.009	0.006	0.006	0.005	0.005	0.006	0.005	0.004	0.003	0.003	0.003	0.003
7	0.037	0.019	0.010	0.011	0.006	0.008	0.004	0.004	0.005	0.005	0.006	0.004	0.006	0.004	0.003	0.003	0.002	0.003
8	0.030	0.015	0.010	0.008	0.008	0.008	0.006	0.007	0.005	0.008	0.005	0.008	0.003	0.006	0.003	0.003	0.003	0.002
9	0.089	0.055	0.030	0.019	0.022	0.013	0.012	0.008	0.011	0.006	0.005	0.005	0.003	0.002	0.002	0.003	0.003	0.002
10	0.175	0.073	0.054	0.034	0.032	0.024	0.020	0.016	0.016	0.011	0.008	0.008	0.008	0.011	0.006	0.006	0.007	0.003
11	0.075	0.033	0.062	0.049	0.021	0.027	0.009	0.007	0.005	0.008	0.004	0.009	0.004	0.006	0.003	0.003	0.002	0.002
12	0.036	0.019	0.011	0.009	0.006	0.006	0.005	0.004	0.004	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002
13	0.060	0.033	0.023	0.016	0.016	0.027	0.027	0.020	0.036	0.017	0.020	0.019	0.019	0.013	0.016	0.011	0.010	0.010
14																		
15	0.085	0.074	0.033	0.025	0.018	0.011	0.012	0.009	0.008	0.009	0.010	0.008	0.007	0.007	0.005	0.005	0.005	0.004
16	0.053	0.034	0.029	0.021	0.019	0.014	0.011	0.011	0.013	0.013	0.011	0.012	0.007	0.008	0.007	0.007	0.007	0.007
17	0.143	0.120	0.036	0.020	0.012	0.010	0.007	0.006	0.005	0.005	0.004	0.004	0.003	0.003	0.003	0.003	0.002	0.003
18	0.106	0.040	0.027	0.014	0.010	0.012	0.009	0.007	0.007	0.006	0.006	0.005	0.005	0.004	0.005	0.004	0.003	0.003
19	0.111	0.037	0.029	0.018	0.016	0.011	0.019	0.012	0.009	0.006	0.004	0.003	0.002	0.003	0.003	0.003	0.003	0.003
Average	0.074	0.039	0.025	0.017	0.013	0.013	0.010	0.007	0.008	0.007	0.006	0.006	0.005	0.005	0.004	0.004	0.003	0.003
St. Dev.	0.043	0.028	0.016	0.011	0.007	0.009	0.007	0.005	0.008	0.004	0.005	0.005	0.004	0.003	0.003	0.003	0.002	0.002

Table 40: Time to return to pre-kneeling baseline values for standing task for the RVM muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1																		
2	0.040	0.022	0.017	0.010	0.010	0.037	0.004	0.006	0.005	0.005	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.002
3	0.150	0.110	0.084	0.065	0.049	0.039	0.037	0.031	0.032	0.033	0.028	0.027	0.026	0.024	0.023	0.016	0.018	0.019
4	0.105	0.020	0.025	0.025	0.020	0.009	0.005	0.006	0.006	0.007	0.006	0.003	0.009	0.010	0.009	0.010	0.007	0.002
5	0.496	0.252	0.168	0.125	0.101	0.084	0.071	0.063	0.056	0.050	0.046	0.042	0.039	0.036	0.034	0.032	0.030	0.028
6	0.063	0.029	0.016	0.009	0.012	0.011	0.014	0.008	0.009	0.008	0.007	0.005	0.003	0.003	0.003	0.002	0.004	0.004
7	0.442	0.316	0.236	0.153	0.149	0.132	0.124	0.111	0.085	0.082	0.081	0.070	0.061	0.062	0.061	0.058	0.056	0.053
8	0.055	0.031	0.029	0.016	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000
9	0.036	0.027	0.023	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.016	0.031	0.005	0.000	0.000	0.000	0.000	0.000
10	0.080	0.115	0.011	0.012	0.013	0.005	0.024	0.003	0.003	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.002
11	0.029	0.008	0.005	0.007	0.003	0.003	0.002	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001
12	0.040	0.005	0.011	0.012	0.011	0.009	0.008	0.006	0.006	0.005	0.005	0.004	0.004	0.004	0.004	0.003	0.003	0.003
13	0.099	0.043	0.029	0.020	0.012	0.009	0.010	0.011	0.007	0.005	0.007	0.003	0.004	0.024	0.012	0.010	0.005	0.006
14																		
15	0.012	0.005	0.003	0.012	0.009	0.008	0.007	0.006	0.004	0.003	0.004	0.004	0.003	0.001	0.001	0.001	0.000	0.000
16	0.008	0.004	0.003	0.002	0.001	0.003	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.006	0.001	0.000	0.005	0.003
17	0.051	0.030	0.019	0.006	0.035	0.013	0.012	0.004	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	0.182	0.048	0.044	0.011	0.009	0.003	0.000	0.004	0.001	0.005	0.000	0.001	0.001	0.002	0.002	0.002	0.003	0.004
19	0.240	0.056	0.051	0.034	0.027	0.019	0.012	0.005	0.005	0.005	0.006	0.006	0.004	0.001	0.003	0.002	0.001	0.001
Average	0.125	0.066	0.045	0.031	0.027	0.023	0.020	0.016	0.013	0.013	0.013	0.012	0.010	0.010	0.009	0.008	0.008	0.008
St. Dev.	0.144	0.089	0.063	0.044	0.040	0.035	0.032	0.029	0.023	0.022	0.021	0.019	0.017	0.017	0.016	0.015	0.015	0.014

Table 41: Time to return to pre-kneeling baseline values for sitting task for the RRF muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.014	0.009	0.006	0.005	0.004	0.003	0.003	0.002	0.002	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001
2	0.022	0.009	0.008	0.007	0.005	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001
3	0.010	0.009	0.010	0.024	0.009	0.011	0.011	0.011	0.010	0.009	0.009	0.008	0.008	0.007	0.007	0.007	0.006	0.006
4	0.011	0.003	0.003	0.002	0.002	0.011	0.058	0.046	0.037	0.032	0.018	0.029	0.028	0.027	0.024	0.021	0.020	0.018
5	0.116	0.079	0.050	0.006	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001
6	0.020	0.011	0.005	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
7	0.158	0.027	0.007	0.017	0.020	0.021	0.019	0.019	0.017	0.016	0.015	0.014	0.013	0.013	0.012	0.011	0.010	0.010
8	0.004	0.001	0.024	0.022	0.022	0.019	0.018	0.017	0.015	0.014	0.013	0.012	0.011	0.010	0.010	0.009	0.008	0.008
9	0.005	0.006	0.005	0.004	0.004	0.003	0.002	0.002	0.016	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
10	0.099	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
11	0.270	0.131	0.041	0.004	0.003	0.005	0.004	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
12	0.093	0.049	0.035	0.028	0.024	0.014	0.016	0.014	0.013	0.012	0.009	0.009	0.009	0.009	0.008	0.007	0.007	0.007
13	0.112	0.059	0.030	0.029	0.024	0.021	0.018	0.015	0.014	0.013	0.012	0.011	0.010	0.009	0.008	0.008	0.007	0.007
14																		
15	0.022	0.002	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
16	0.025	0.013	0.010	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.002	0.001	0.000	0.000	0.000
17	0.011	0.004	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
18	0.021	0.018	0.000	0.002	0.005	0.005	0.005	0.005	0.005	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.002
19	0.043	0.038	0.027	0.021	0.008	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000
Average	0.059	0.026	0.015	0.010	0.008	0.007	0.009	0.008	0.008	0.007	0.005	0.006	0.005	0.005	0.005	0.004	0.004	0.004
St. Dev.	0.071	0.034	0.016	0.010	0.008	0.007	0.014	0.011	0.010	0.008	0.006	0.007	0.007	0.007	0.006	0.005	0.005	0.005

Table 42: Time to return to pre-kneeling baseline values for walking task for the RRF muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.110	0.046	0.039	0.025	0.017	0.013	0.011	0.009	0.007	0.007	0.007	0.005	0.005	0.004	0.004	0.002	0.001	0.001
2	0.037	0.016	0.011	0.008	0.007	0.006	0.005	0.004	0.003	0.003	0.003	0.003	0.002	0.003	0.002	0.002	0.002	0.002
3	0.027	0.011	0.001	0.002	0.003	0.001	0.000	0.005	0.004	0.004	0.004	0.003	0.003	0.003	0.004	0.003	0.003	0.003
4	0.004	0.006	0.004	0.008	0.007	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.000	0.000	0.000	0.001	0.001	0.000
5	0.047	0.018	0.015	0.012	0.008	0.005	0.006	0.005	0.003	0.004	0.003	0.004	0.002	0.003	0.002	0.004	0.002	0.002
6	0.107	0.032	0.013	0.007	0.004	0.003	0.003	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.001	0.001	0.001	0.001
7	0.073	0.011	0.008	0.005	0.004	0.002	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.000	0.001	0.001	0.001
8	0.027	0.012	0.004	0.001	0.007	0.002	0.001	0.001	0.001	0.001	0.002	0.001	0.002	0.002	0.002	0.002	0.001	0.002
9	0.091	0.044	0.026	0.021	0.017	0.015	0.011	0.011	0.009	0.007	0.006	0.005	0.005	0.005	0.003	0.005	0.004	0.003
10	0.125	0.046	0.051	0.025	0.015	0.013	0.008	0.007	0.007	0.006	0.005	0.005	0.005	0.004	0.006	0.005	0.005	0.004
11	0.054	0.029	0.040	0.035	0.015	0.013	0.009	0.007	0.006	0.006	0.004	0.005	0.003	0.004	0.003	0.004	0.003	0.003
12	0.032	0.014	0.009	0.007	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.003	0.003	0.001	0.001	0.002	0.002	0.002
13	0.091	0.050	0.028	0.019	0.015	0.009	0.008	0.008	0.013	0.008	0.008	0.010	0.010	0.006	0.005	0.007	0.006	0.006
14																		
15	0.127	0.097	0.040	0.026	0.017	0.009	0.008	0.005	0.005	0.004	0.004	0.003	0.003	0.004	0.002	0.002	0.002	0.002
16	0.049	0.022	0.019	0.016	0.011	0.010	0.010	0.006	0.006	0.008	0.006	0.006	0.005	0.005	0.005	0.005	0.005	0.005
17	0.079	0.076	0.022	0.028	0.013	0.010	0.010	0.008	0.008	0.007	0.007	0.005	0.006	0.006	0.006	0.005	0.004	0.005
18	0.039	0.023	0.027	0.020	0.016	0.012	0.009	0.005	0.011	0.006	0.004	0.003	0.006	0.004	0.004	0.005	0.003	0.003
19	0.117	0.045	0.033	0.021	0.017	0.014	0.020	0.012	0.010	0.006	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Average	**0.069**	**0.033**	**0.022**	**0.016**	**0.011**	**0.008**	**0.007**	**0.006**	**0.006**	**0.005**	**0.004**	**0.004**	**0.004**	**0.003**	**0.003**	**0.003**	**0.003**	**0.003**
St. Dev.	**0.038**	**0.024**	**0.015**	**0.010**	**0.005**	**0.005**	**0.005**	**0.003**	**0.003**	**0.002**	**0.002**	**0.002**	**0.002**	**0.002**	**0.002**	**0.002**	**0.001**	**0.001**

Table 43: Time to return to pre-kneeling baseline values for standing task for the RRF muscle

Subject	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1	0.052	0.026	0.018	0.013	0.014	0.010	0.011	0.011	0.007	0.006	0.006	0.004	0.004	0.004	0.004	0.003	0.003	0.003
2	0.003	0.000	0.001	0.001	0.000	0.009	0.001	0.001	0.001	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.002
3	0.030	0.008	0.011	0.012	0.006	0.004	0.005	0.003	0.010	0.013	0.009	0.010	0.011	0.011	0.010	0.002	0.006	0.008
4	0.089	0.020	0.025	0.016	0.017	0.012	0.005	0.006	0.004	0.004	0.004	0.001	0.006	0.008	0.009	0.009	0.005	0.001
5	0.026	0.010	0.007	0.007	0.004	0.003	0.003	0.003	0.002	0.004	0.002	0.002	0.002	0.001	0.003	0.001	0.001	0.001
6	0.077	0.031	0.016	0.011	0.012	0.010	0.015	0.007	0.009	0.007	0.007	0.004	0.002	0.001	0.002	0.001	0.003	0.004
7	0.002	0.024	0.024	0.015	0.017	0.016	0.018	0.016	0.009	0.012	0.012	0.008	0.004	0.008	0.009	0.010	0.009	0.009
8	0.045	0.023	0.016	0.007	0.003	0.000	0.000	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001
9	0.231	0.079	0.068	0.002	0.002	0.007	0.003	0.001	0.001	0.001	0.006	0.004	0.002	0.000	0.001	0.001	0.002	0.001
10	0.101	0.085	0.002	0.001	0.010	0.001	0.002	0.001	0.001	0.001	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.002
11	0.018	0.010	0.005	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
12	0.013	0.004	0.006	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001
13	0.114	0.040	0.026	0.015	0.011	0.006	0.009	0.012	0.005	0.005	0.008	0.002	0.003	0.017	0.014	0.013	0.006	0.010
14																		
15	0.017	0.013	0.011	0.011	0.008	0.007	0.006	0.006	0.005	0.004	0.003	0.004	0.003	0.002	0.003	0.002	0.002	0.001
16	0.007	0.005	0.003	0.002	0.001	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.001	0.000	0.003	0.002
17	0.157	0.046	0.038	0.008	0.036	0.014	0.010	0.004	0.002	0.002	0.001	0.001	0.003	0.000	0.000	0.000	0.005	0.004
18	0.123	0.026	0.022	0.009	0.010	0.007	0.004	0.001	0.002	0.001	0.003	0.002	0.001	0.000	0.002	0.001	0.000	0.000
19	0.155	0.044	0.035	0.020	0.017	0.013	0.009	0.005	0.005	0.004	0.005	0.005	0.002	0.000	0.002	0.002	0.001	0.001
Average	**0.070**	**0.027**	**0.018**	**0.009**	**0.010**	**0.007**	**0.006**	**0.005**	**0.004**	**0.004**	**0.004**	**0.003**	**0.003**	**0.004**	**0.004**	**0.003**	**0.003**	**0.003**
St. Dev.	**0.066**	**0.024**	**0.016**	**0.006**	**0.009**	**0.005**	**0.005**	**0.004**	**0.003**	**0.004**	**0.003**	**0.003**	**0.002**	**0.004**	**0.004**	**0.004**	**0.002**	**0.003**

Appendix C: ROM percent differences

Table 44: ROM and percent difference in ROM for all post-kneeling tasks for the knee joint

	Sit				Walk				Stand			
	Pre	Post	Diff	% Diff	Pre	Post	Diff	% Diff	Pre	Post	Diff	% Diff
1	70	74	4	6%	69	71	2	3%	65	67	2	3%
2	79	83	4	5%	78	82	4	5%	75	83	8	11%
3	80	76	-4	-5%	73	75	2	3%	73	73	0	0%
4	92	86	-6	-7%	91	93	2	2%	85	88	3	4%
5	84	85	1	1%	91	83	-8	-9%	86	89	3	3%
6	74	72	-2	-3%	68	79	11	16%	71	73	2	3%
7	89	85	-4	-4%	90	92	2	2%	93	92	-1	-1%
8	99	95	-4	-4%	97	93	-4	-4%	93	92	-1	-1%
9	85	81	-4	-5%	87	83	-4	-5%	80	79	-1	-1%
10	92	89	-3	-3%	90	82	-8	-9%	92	85	-7	-8%
11	81	80	-1	-1%	87	87	0	0%	82	83	1	1%
12	72	72	0	0%	74	79	5	7%	73	77	4	5%
13	78	83	5	6%	83	84	1	1%	82	88	6	7%
14	81	82	1	1%	85	81	-4	-5%	82	82	0	0%
15	93	101	8	9%	93	104	11	12%	106	100	-6	-6%
16	83	87	4	5%	74	87	13	18%	77	83	6	8%
17	78	79	1	1%	76	76	0	0%	75	78	3	4%
18	N/A	80			79	72	-7	-9%	86	82	-4	-5%
19	81	83	2	2%	85	85	0	0%	86	85	-1	-1%
Avg	82.8	82.9	0.1	0%	82.6	83.5	0.9	2%	82.2	83.1	0.8	1%
SD	7.73	7.43	3.8	5%	8.60	8.05	6.1	8%	9.64	7.74	3.9	5%

Table 45: ROM and percent difference in ROM for all post-kneeling tasks for the ankle joint

	Sit				Walk				Stand			
	Pre	Post	Diff	% Diff	Pre	Post	Diff	% Diff	Pre	Post	Diff	% Diff
1	68	69	1	1%	68	64	-4	-6%	67	67	0	0%
2	71	72	1	1%	72	74	2	3%	69	71	2	3%
3	65	64	-1	-2%	64	63	-1	-2%	62	59	-3	-5%
4	90	89	-1	-1%	92	92	0	0%	90	89	-1	-1%
5	76	79	3	4%	78	73	-5	-6%	78	76	-2	-3%
6	59	53	-6	-10%	62	65	3	5%	59	59	0	0%
7	77	76	-1	-1%	75	76	1	1%	79	76	-3	-4%
8	72	70	-2	-3%	72	65	-7	-10%	74	72	-2	-3%
9	77	67	-10	-13%	70	74	4	6%	70	71	1	1%
10	82	81	-1	-1%	78	76	-2	-3%	78	77	-1	-1%
11	65	62	-3	-5%	66	62	-4	-6%	64	61	-3	-5%
12	70	74	4	6%	62	68	6	10%	64	63	-1	-2%
13	75	72	-3	-4%	70	71	1	1%	70	67	-3	-4%
14	67	60	-7	-10%	68	68	0	0%	69	70	1	1%
15	90	90	0	0%	92	91	-1	-1%	88	92	4	5%
16	55	60	5	9%	60	63	3	5%	51	54	3	6%
17	76	71	-5	-7%	76	75	-1	-1%	75	73	-2	-3%
18	N/A	61			55	56	1	2%	60	63	3	5%
19	78	78	0	0%	76	75	-1	-1%	74	77	3	4%
Avg	72.9	71.5	-1.4	-2%	71.3	71.1	-0.2	0%	70.5	70.3	-0.2	0%
SD	9.27	9.84	3.8	6%	9.6	9.2	3.2	5%	9.75	9.78	2.3	3%

Appendix D: Average normalized RMS and MDF during post-kneeling task

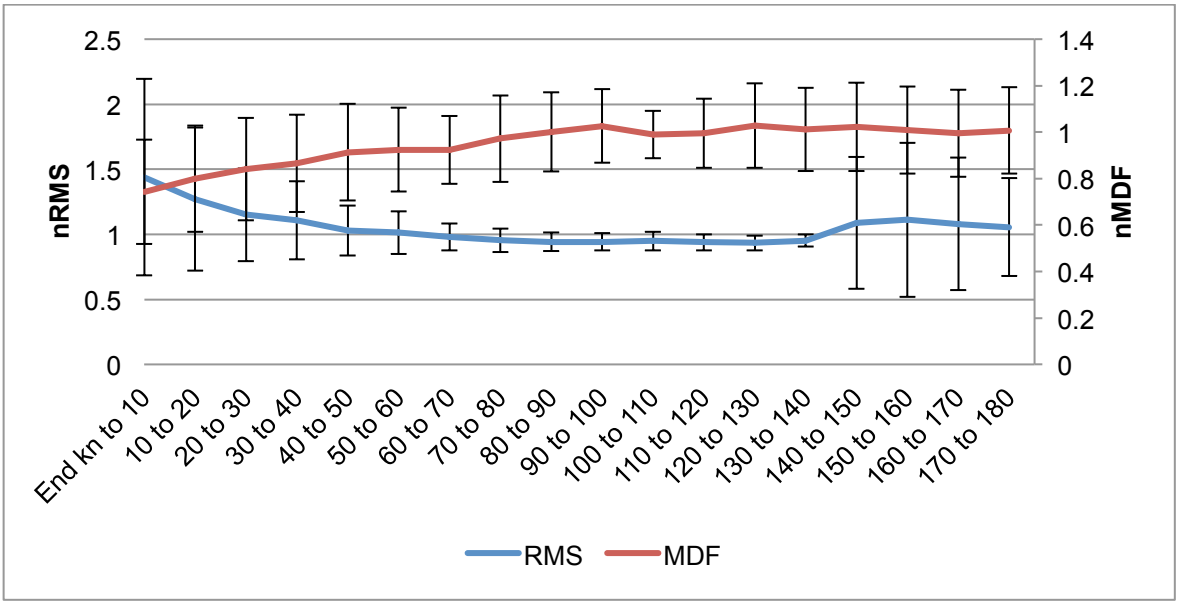

Figure 69: nRMS and nMDF sitting post-kneeling task for the RVL muscle

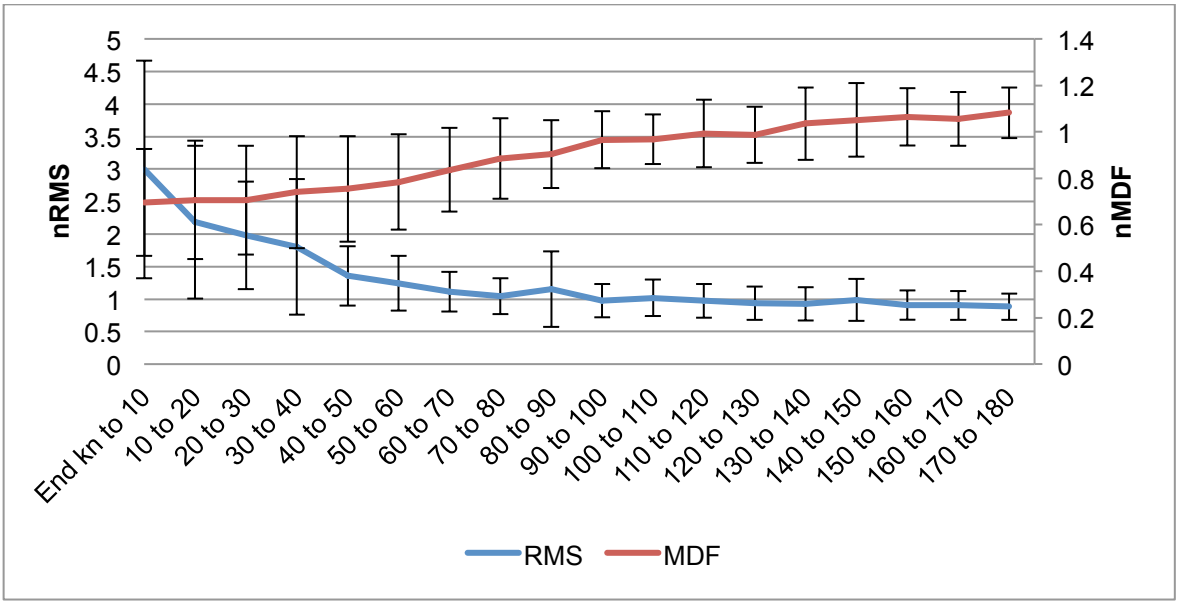

Figure 70: nRMS and nMDF sitting post-kneeling task for the RTA muscle

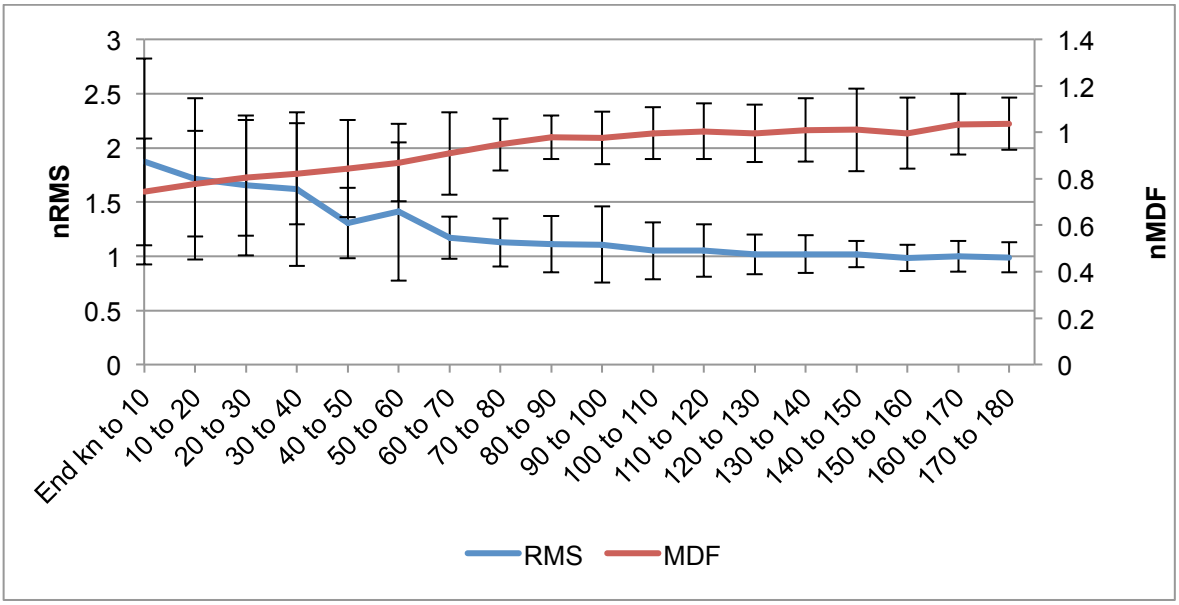

Figure 71: nRMS and nMDF sitting post-kneeling task for the RMG muscle

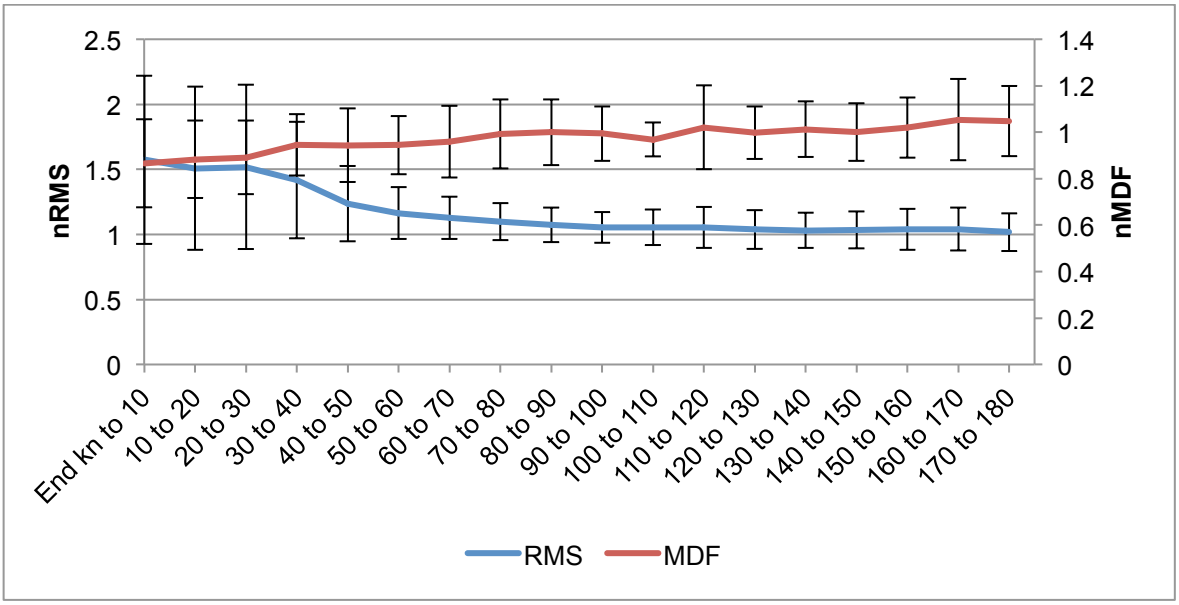

Figure 72: nRMS and nMDF sitting post-kneeling task for the RGL muscle

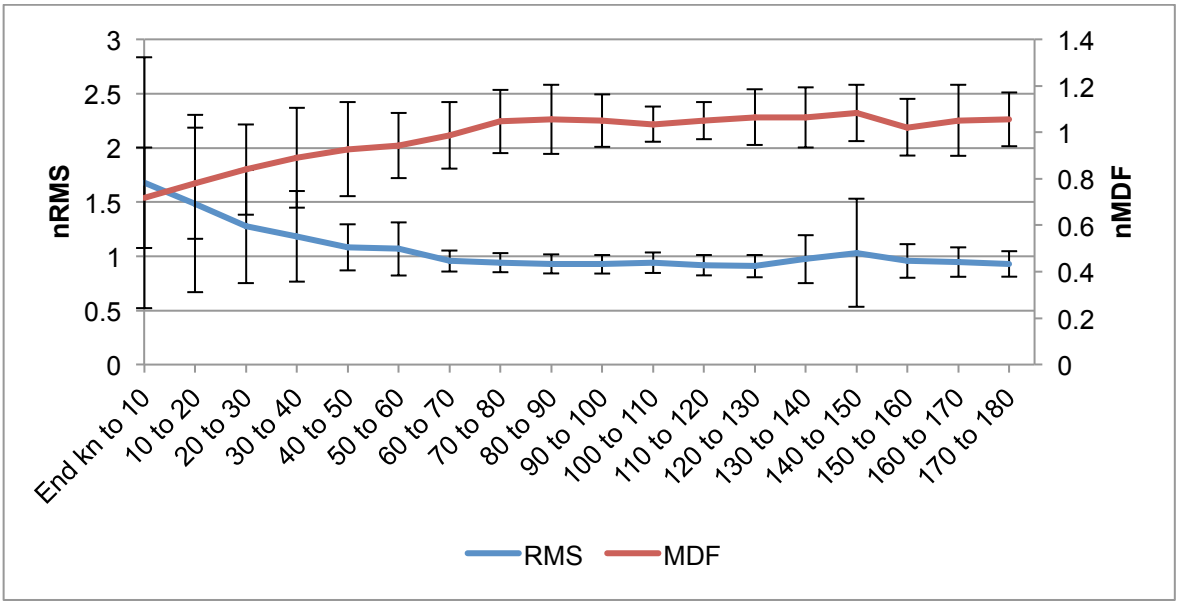

Figure 73: nRMS and nMDF sitting post-kneeling task for the RRA muscle

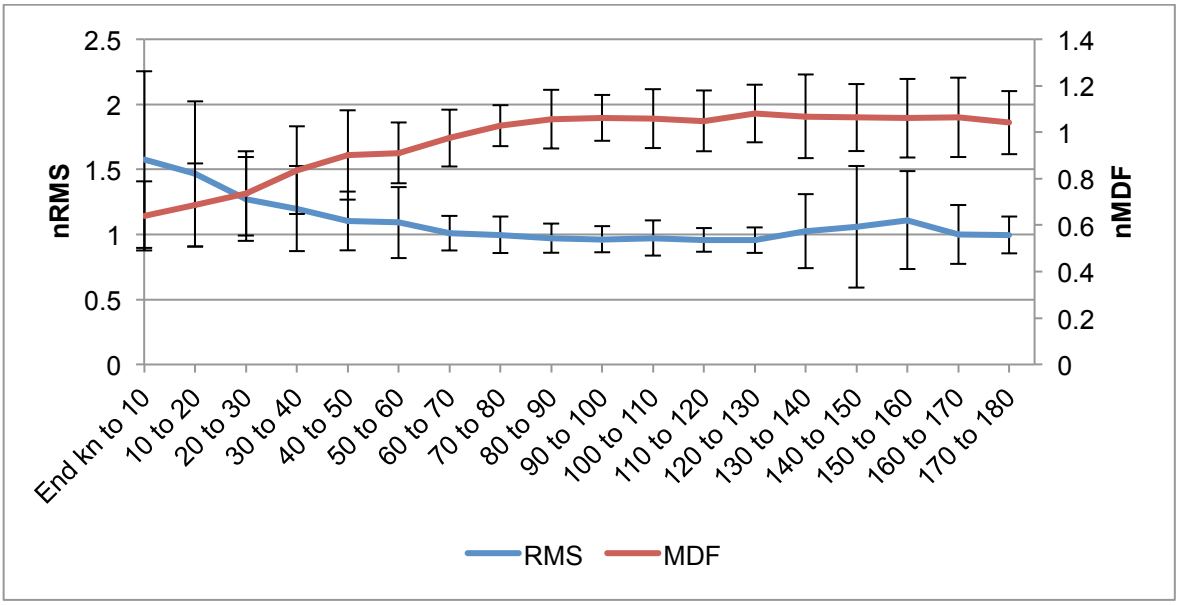

Figure 74: nRMS and nMDF sitting post-kneeling task for the LRA muscle

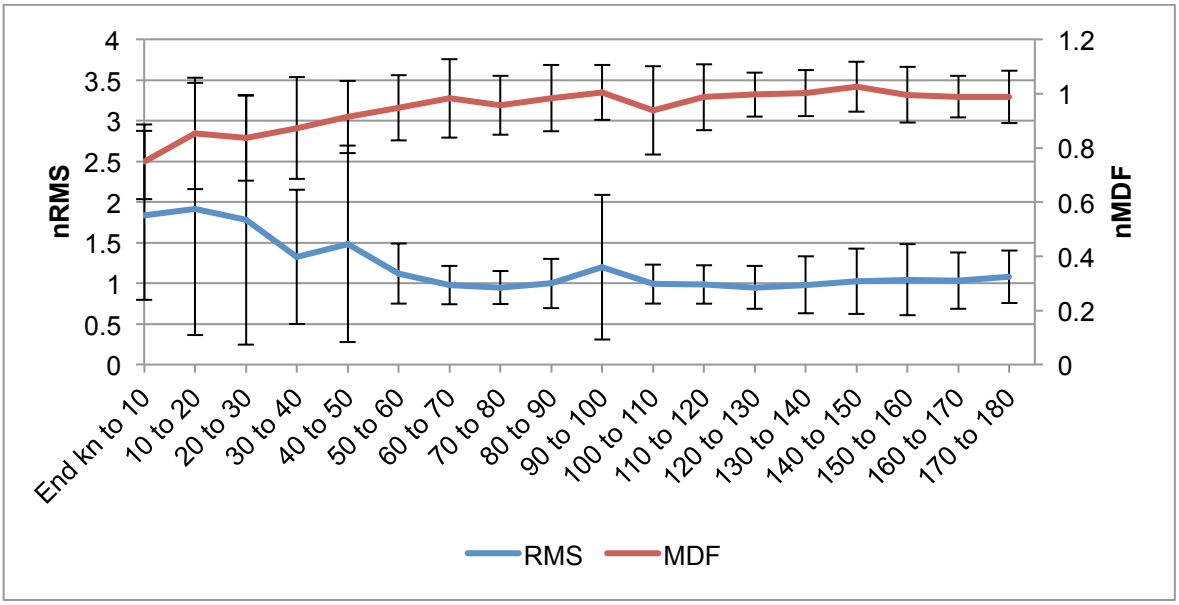

Figure 75: nRMS and nMDF sitting post-kneeling task for the RES muscle

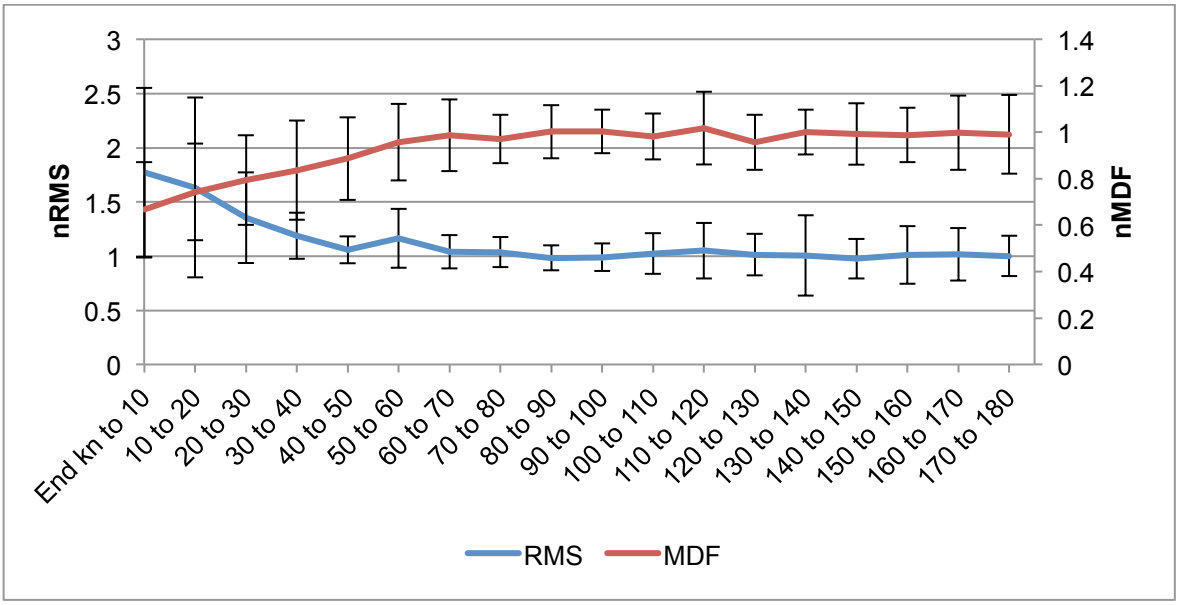

Figure 76: nRMS and nMDF sitting post-kneeling task for the LES muscle

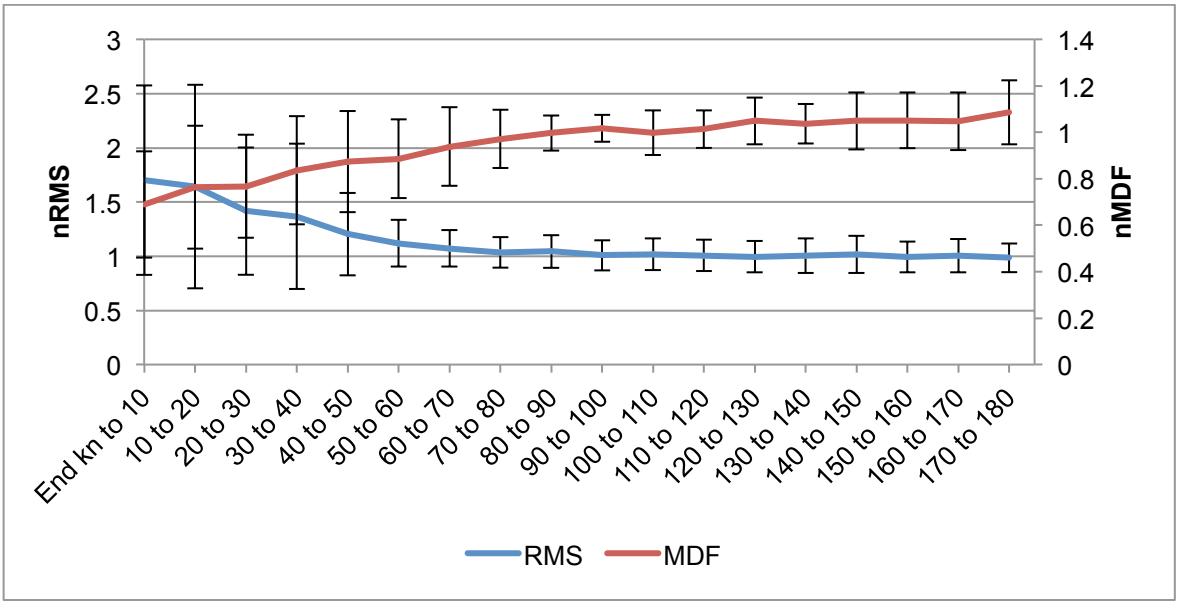

Figure 77: nRMS and nMDF sitting post-kneeling task for the RVM muscle

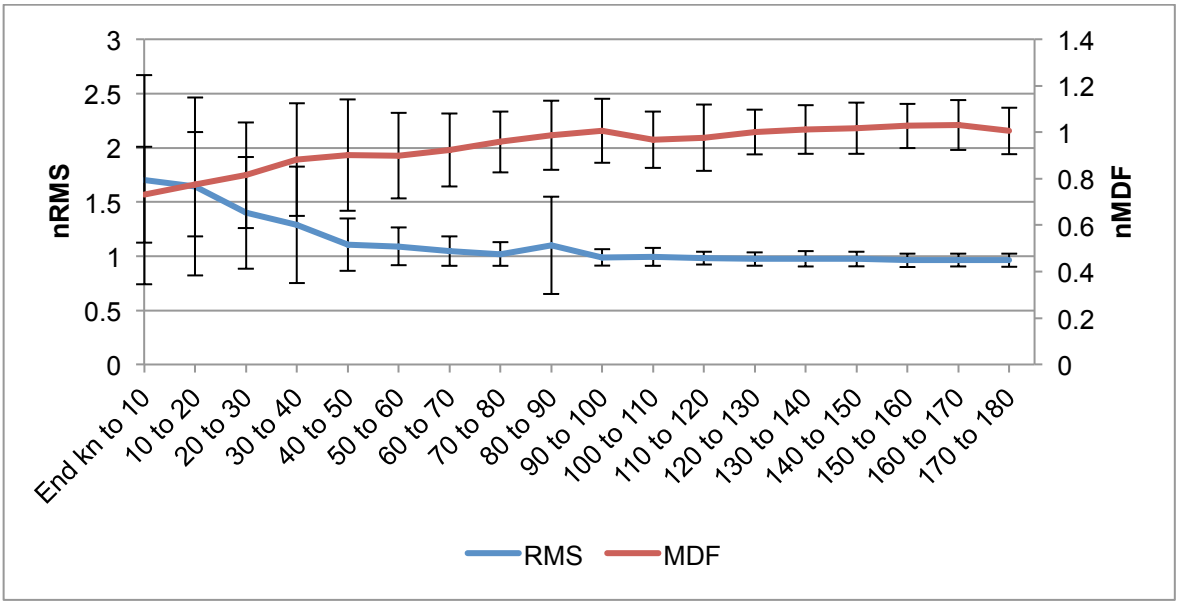

Figure 78: nRMS and nMDF sitting post-kneeling task for the RRF muscle

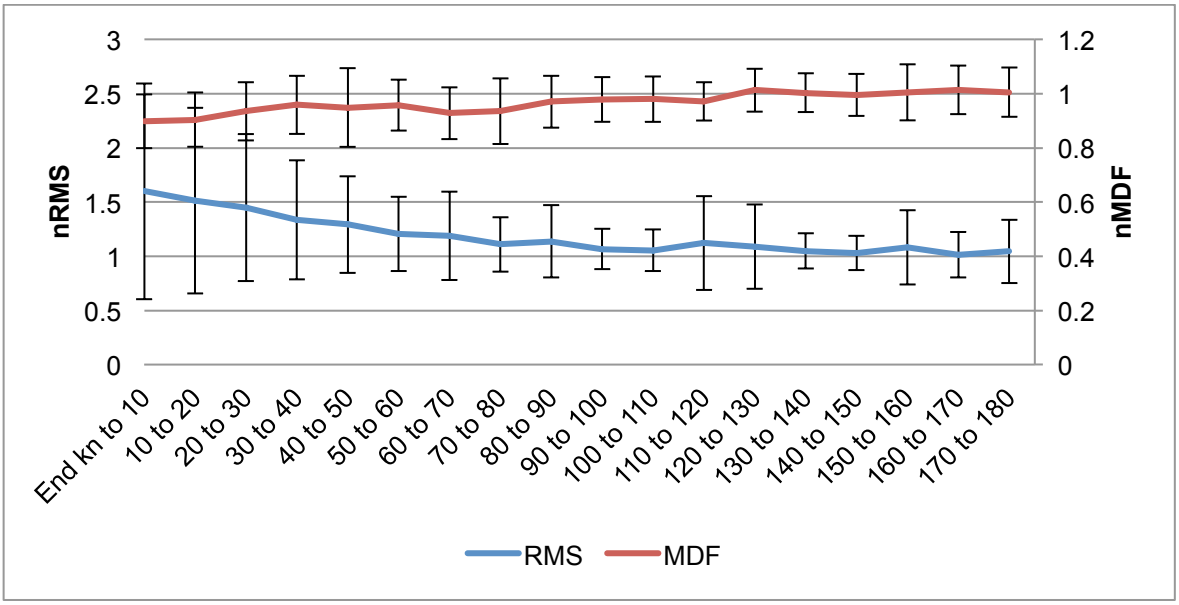

Figure 79: nRMS and nMDF walking post-kneeling task for the RVL muscle

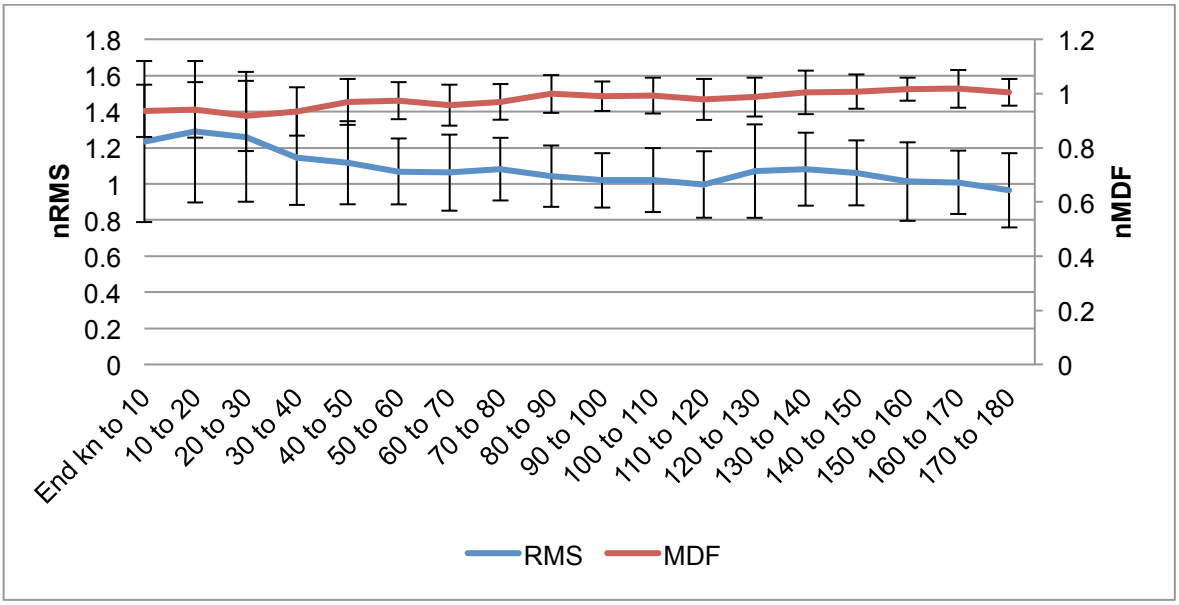

Figure 80: nRMS and nMDF walking post-kneeling task for the RTA muscle

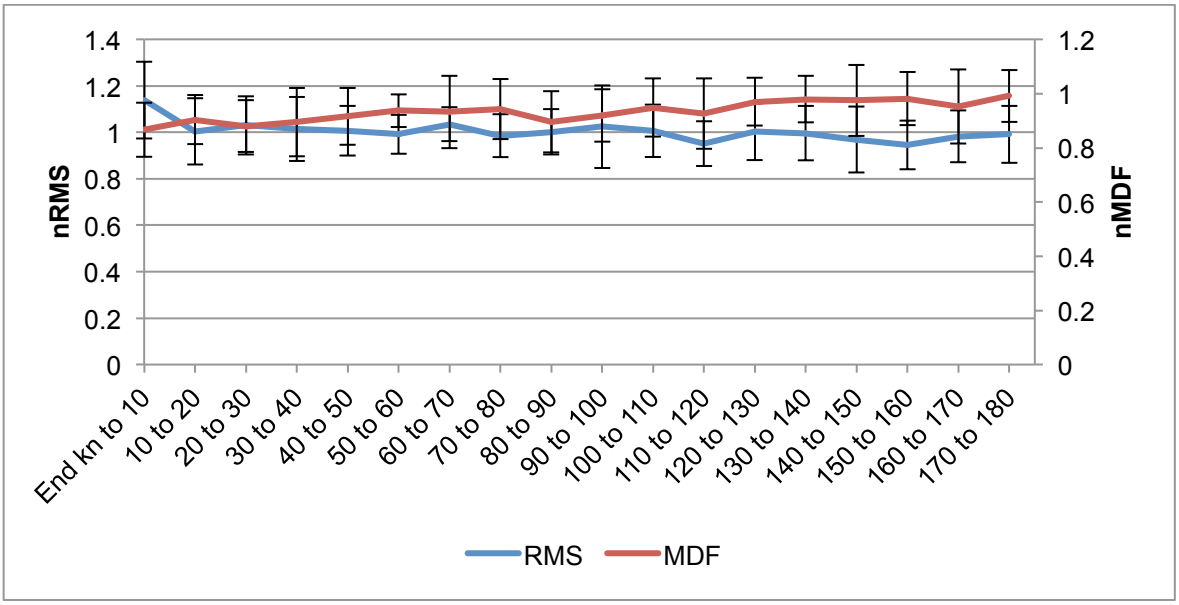

Figure 81: nRMS and nMDF walking post-kneeling task for the RMG muscle

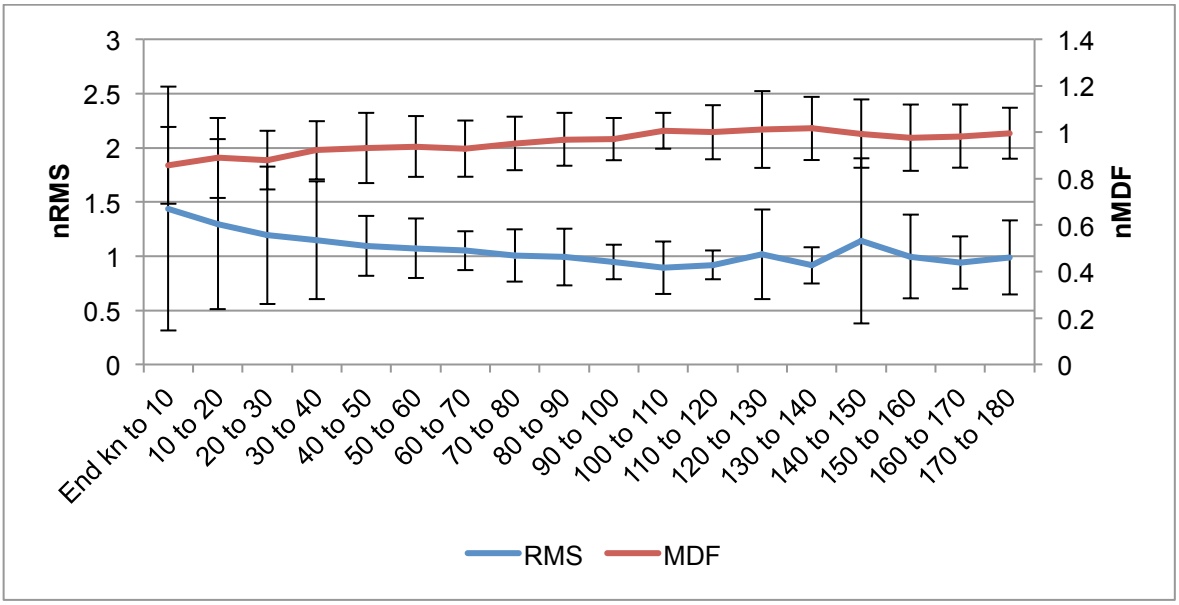

Figure 82: nRMS and nMDF walking post-kneeling task for the RGL muscle

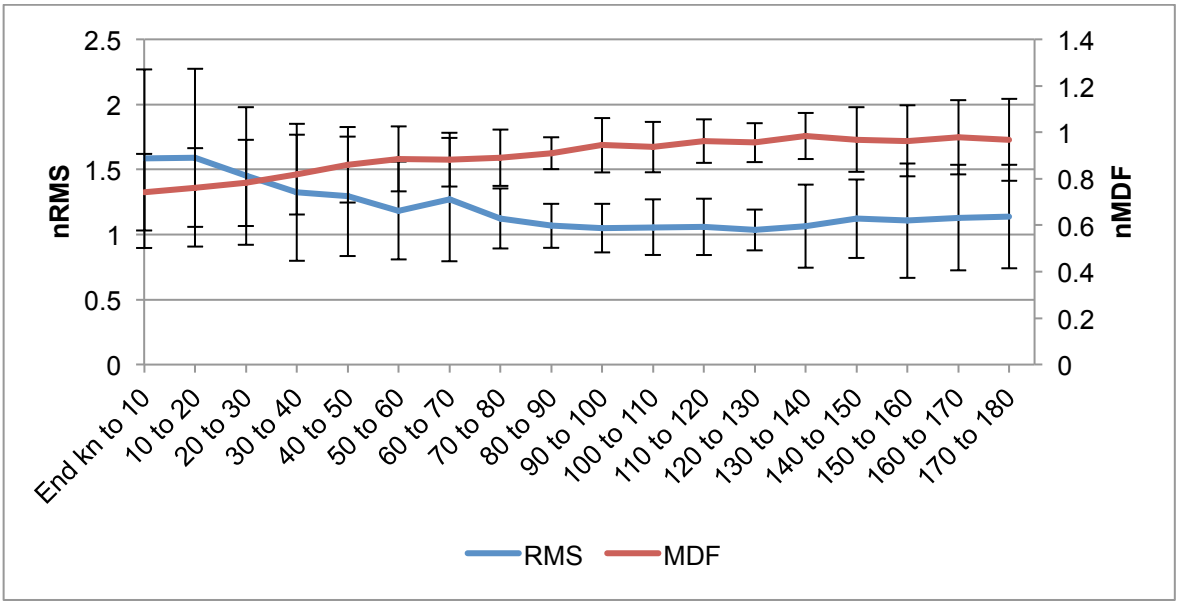

Figure 83: nRMS and nMDF walking post-kneeling task for the RRA muscle

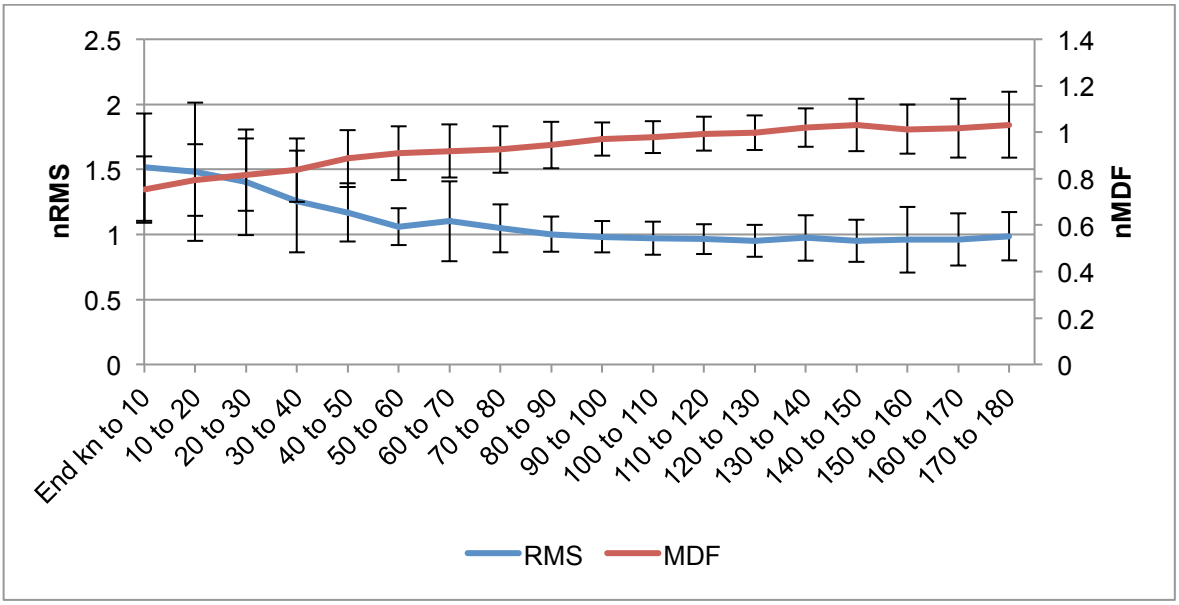

Figure 84: nRMS and nMDF walking post-kneeling task for the LRA muscle

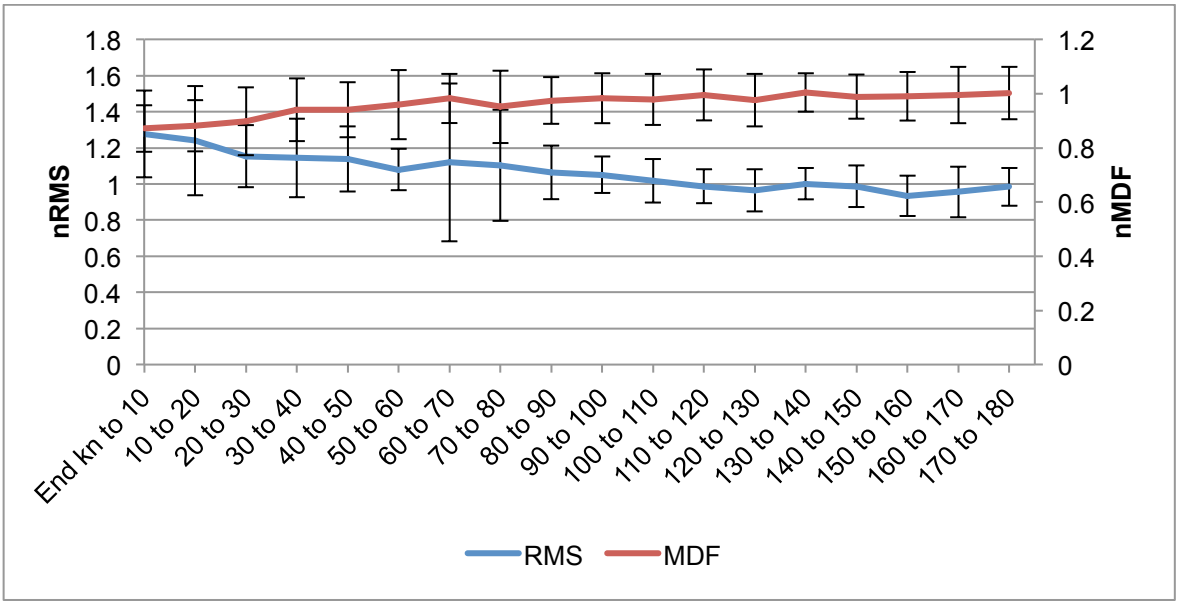

Figure 85: nRMS and nMDF walking post-kneeling task for the RES muscle

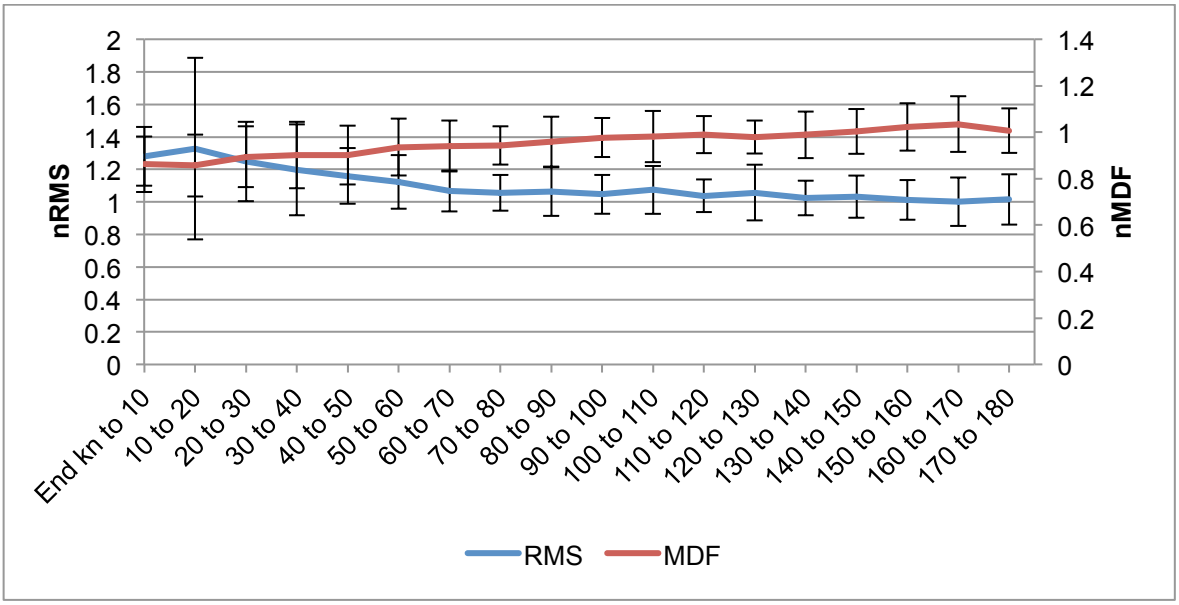

Figure 86: nRMS and nMDF walking post-kneeling task for the LES muscle

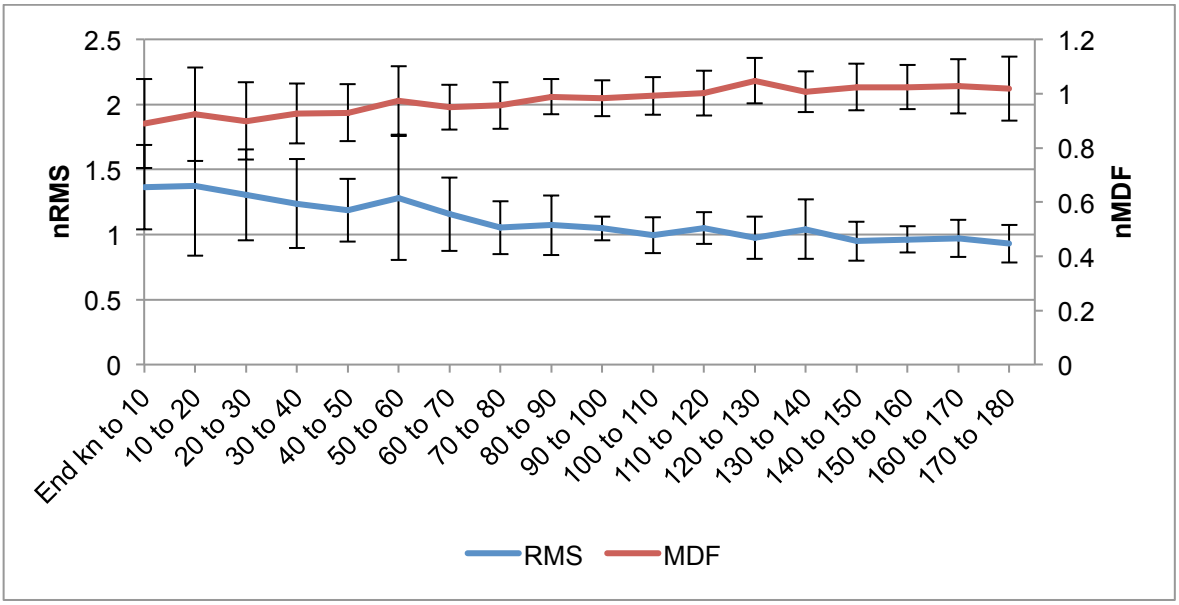

Figure 87: nRMS and nMDF walking post-kneeling task for the RVM muscle

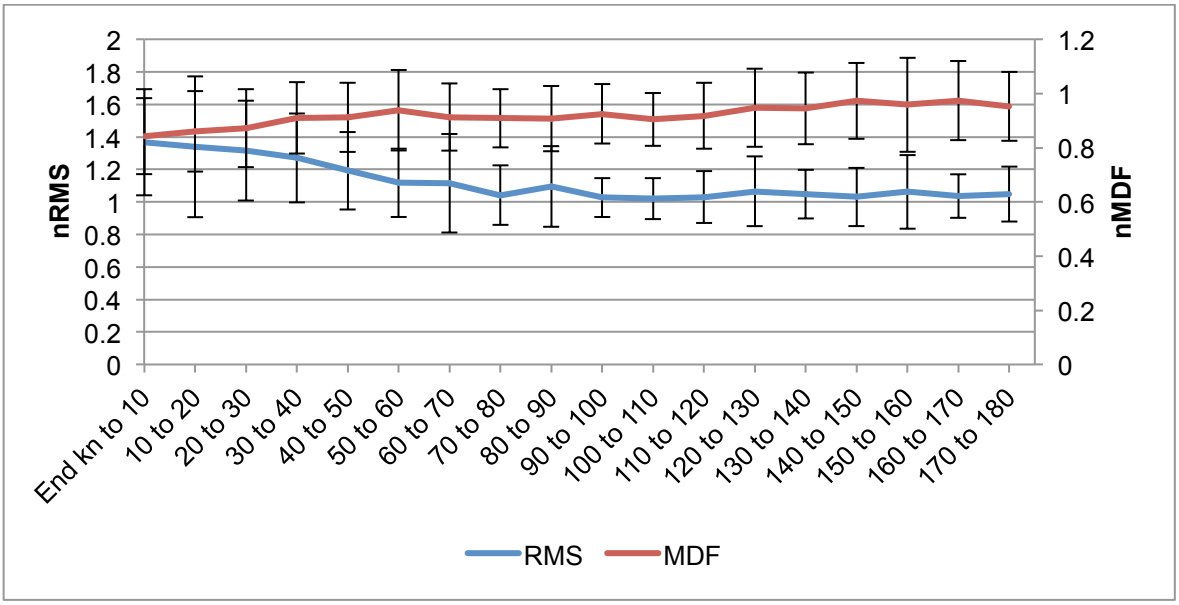

Figure 88: nRMS and nMDF walking post-kneeling task for the RRF muscle

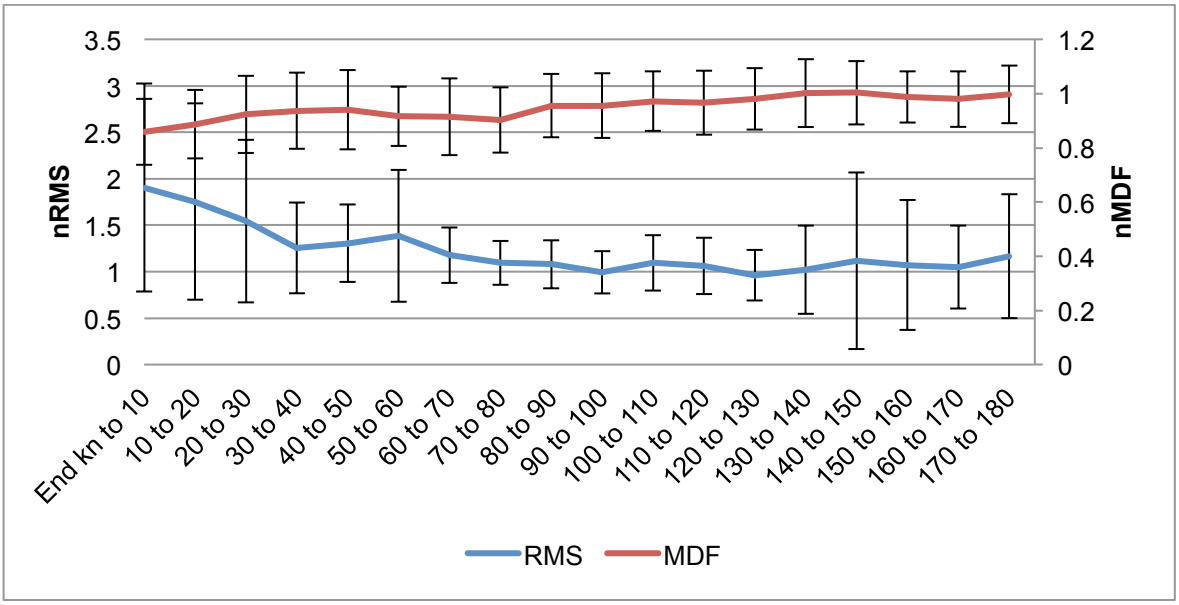

Figure 89: nRMS and nMDF standing post-kneeling task for the RVL muscle

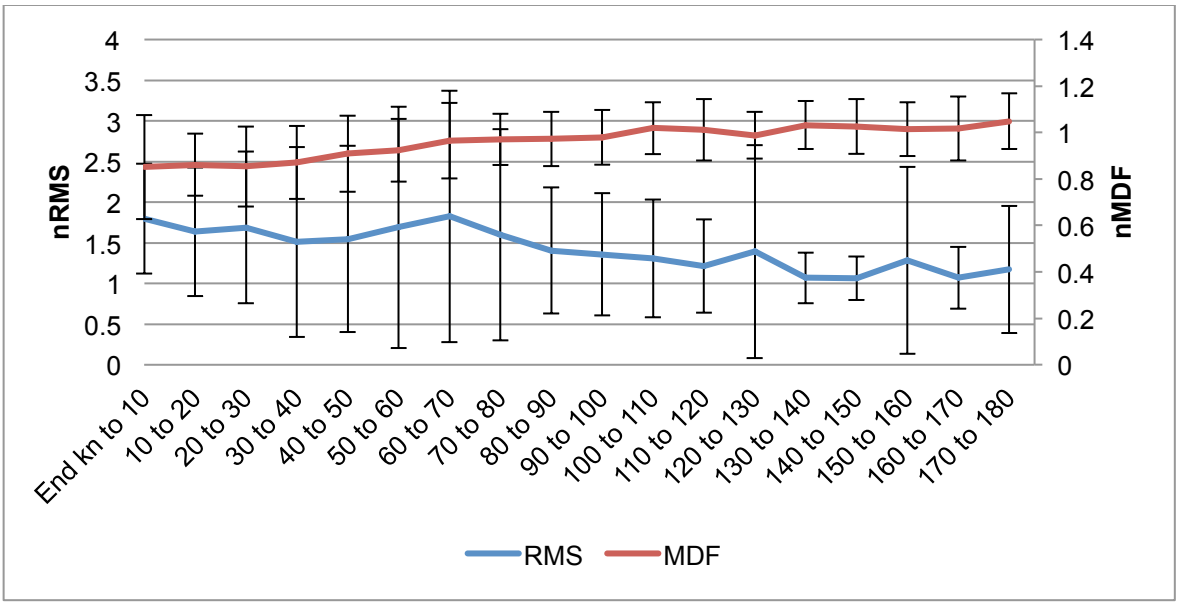

Figure 90: nRMS and nMDF standing post-kneeling task for the RTA muscle

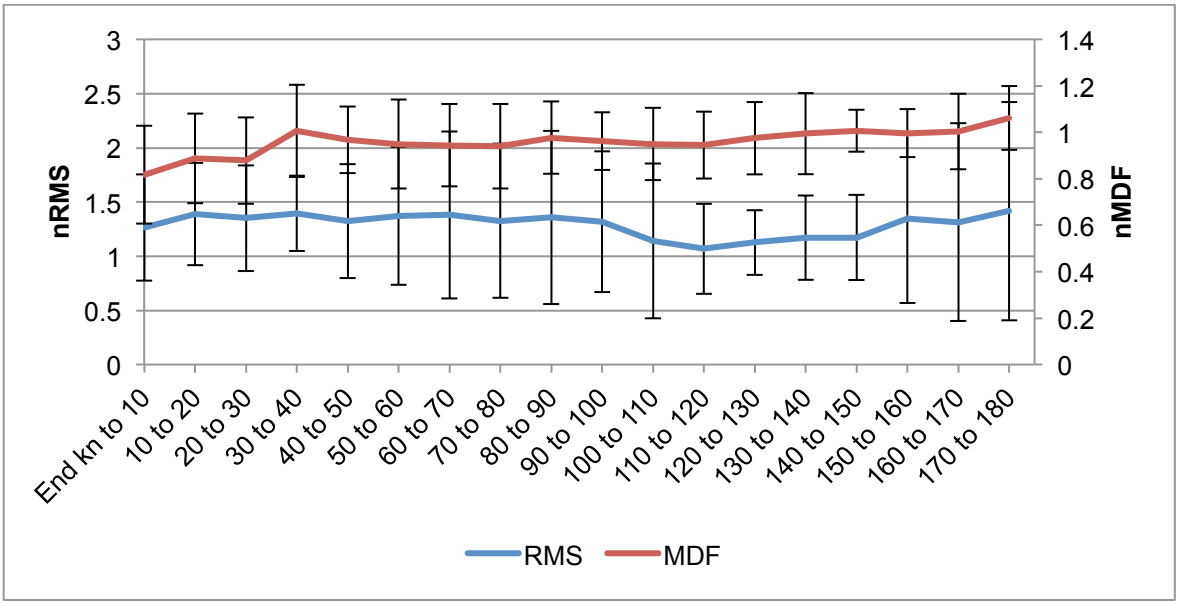

Figure 91: nRMS and nMDF standing post-kneeling task for the RMG muscle

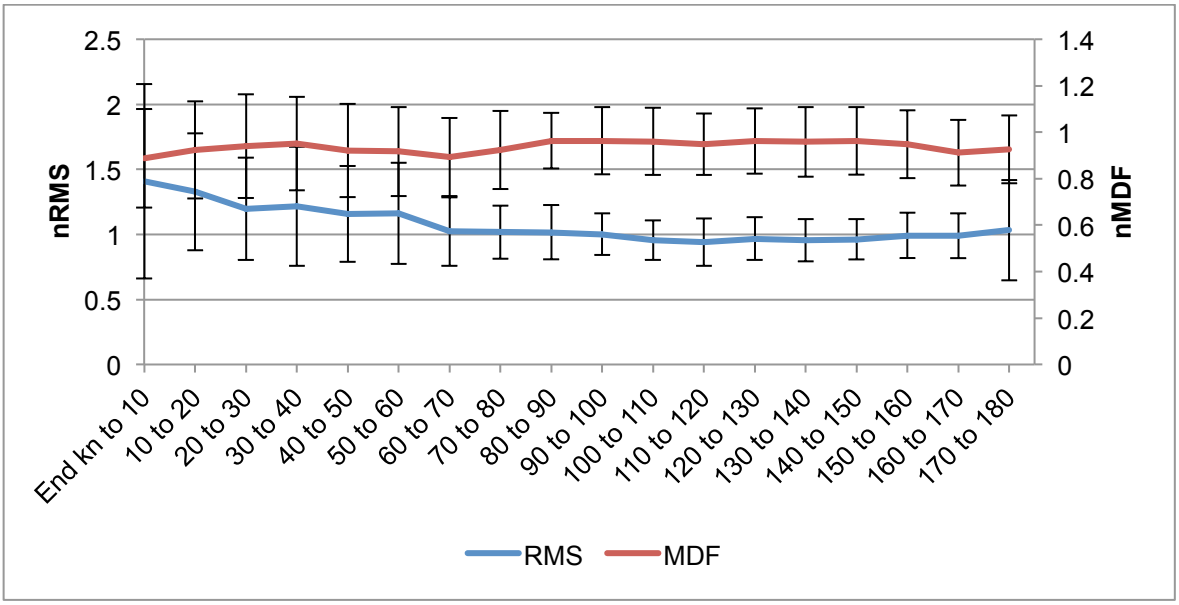

Figure 92: nRMS and nMDF standing post-kneeling task for the RGL muscle

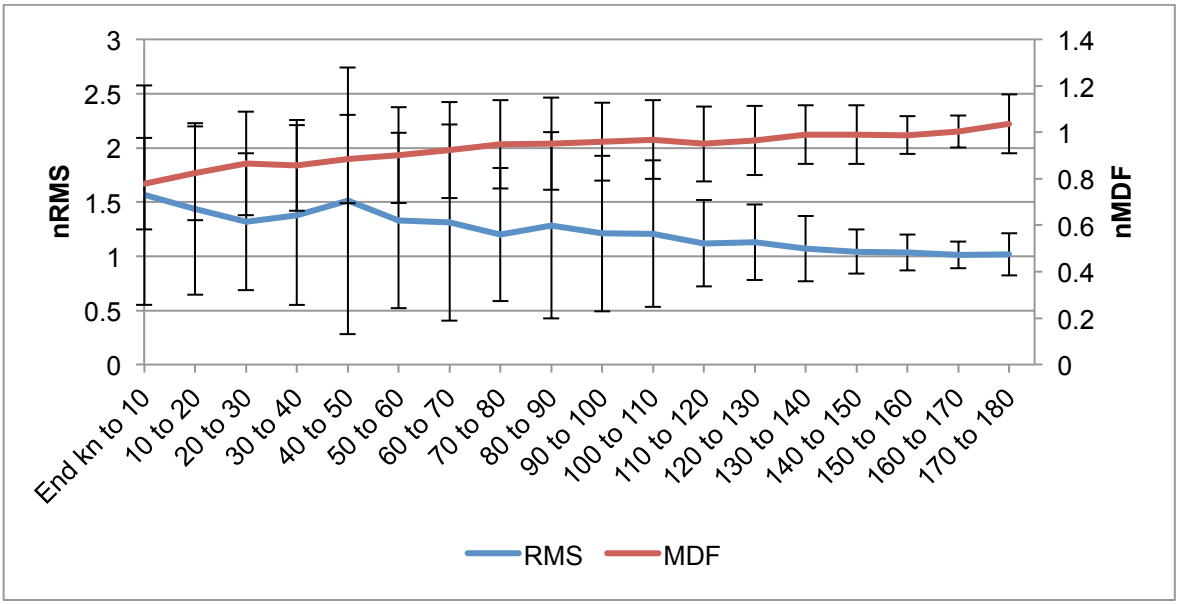

Figure 93: nRMS and nMDF standing post-kneeling task for the RRA muscle

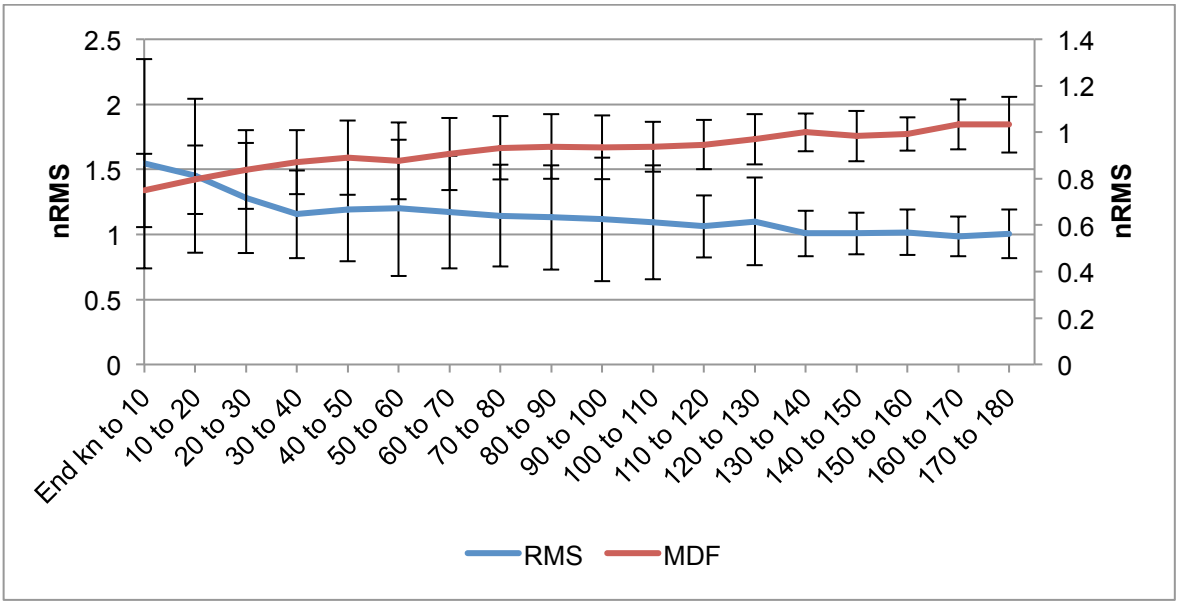

Figure 94: nRMS and nMDF standing post-kneeling task for the LRA muscle

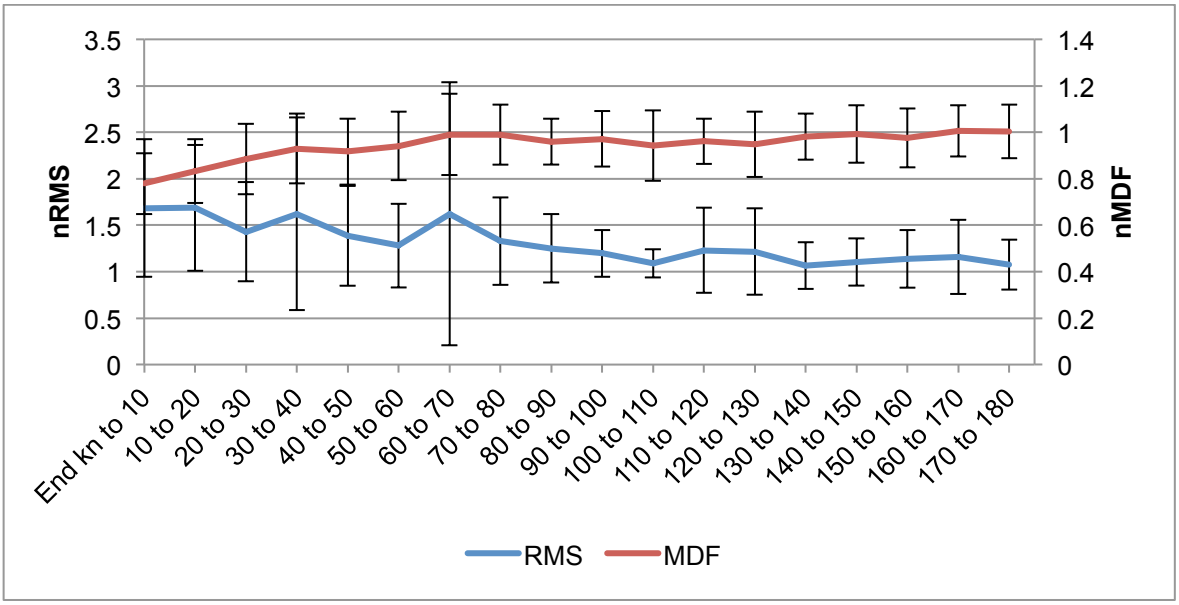

Figure 95: nRMS and nMDF standing post-kneeling task for the RES muscle

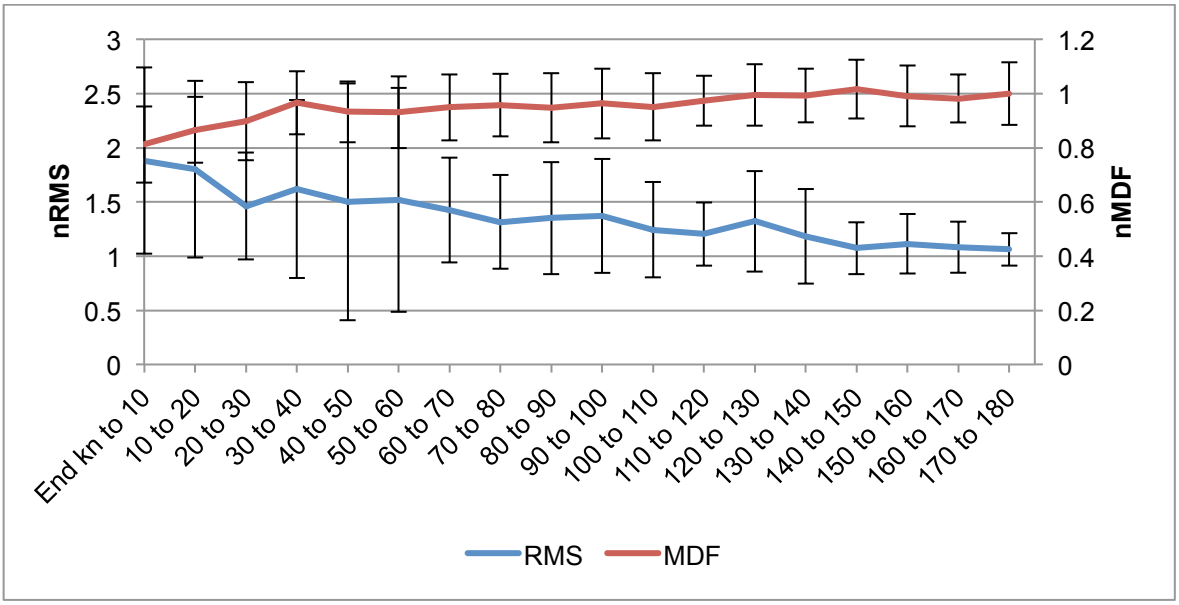

Figure 96: nRMS and nMDF standing post-kneeling task for the LES muscle

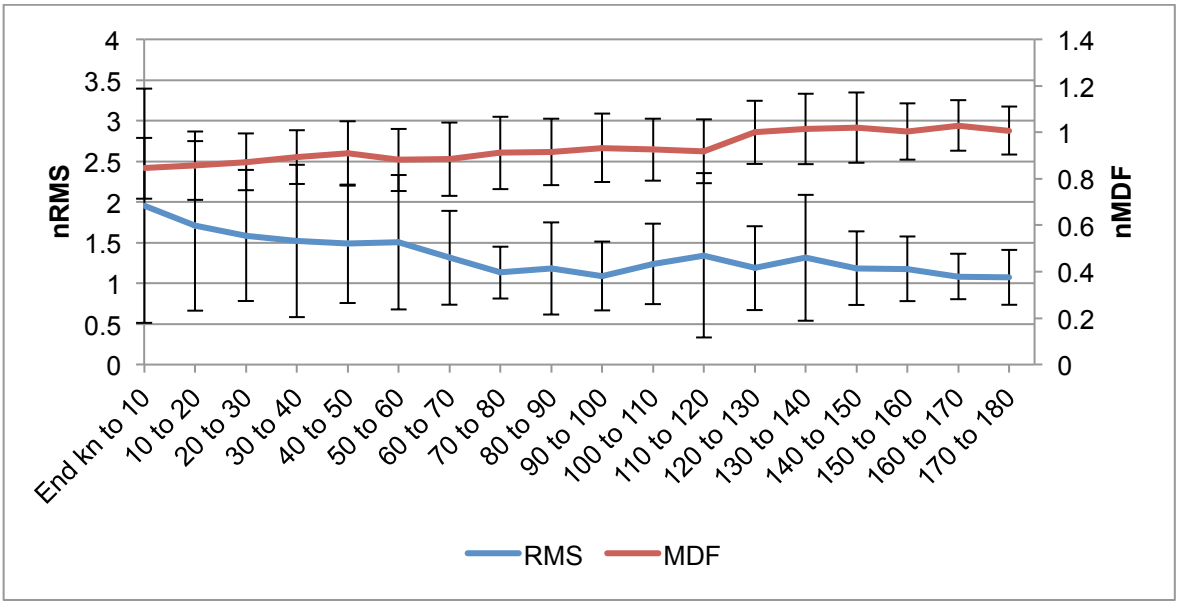

Figure 97: nRMS and nMDF standing post-kneeling task for the RVM muscle

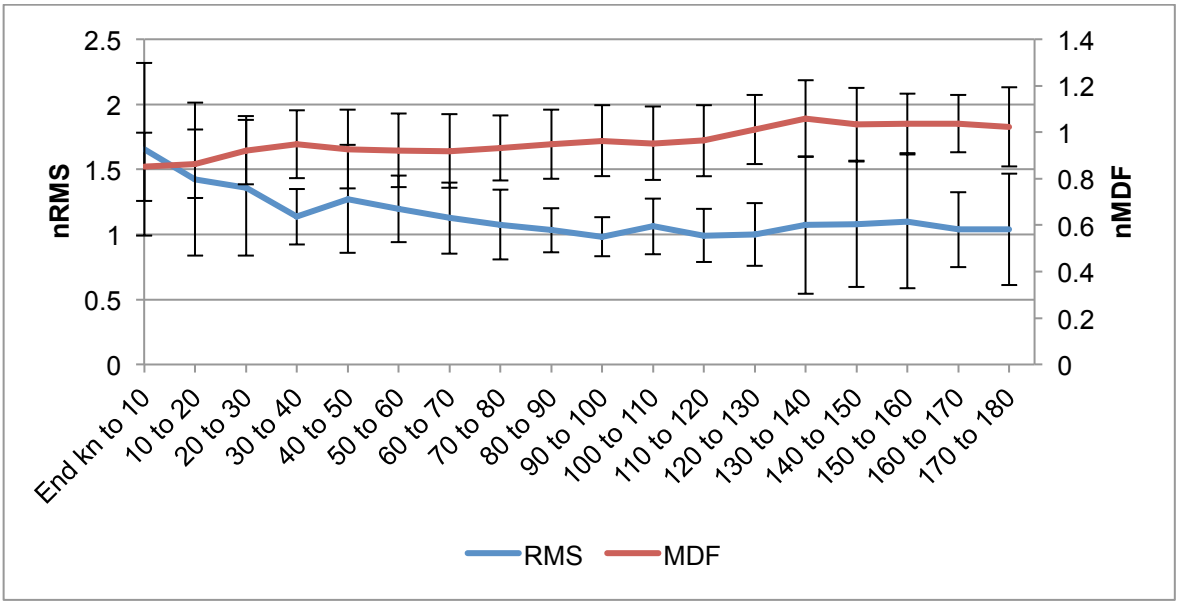

Figure 98: nRMS and nMDF standing post-kneeling task for the RRF muscle