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Relationships between Maximum Holding Time and Ratings of Pain and Exertion Differ for Static and Dynamic Tasks

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Abstract

Ratings of perceived discomfort (0 to 10 scale) have been used to estimate relative maximum holding times (%MHT), particularly for static tasks. A linear 1:10% ratio has been described, where a rating of 5 corresponds to 50%MHT. It is unknown whether this linear ratio is valid for dynamic tasks. Additionally, whether pain or exertion are the primary predictors of discomfort is not clear. Thus, the goal of this study was to investigate both pain and exertion ratings during static (50% maximum; N= 42) and dynamic (75% maximum; N=34) elbow flexion tasks until failure. Gender, self-reported physical activity, and peak torque were also assessed. Pain and exertion ratings reasonably matched the 1:10% ratio during the static task but not during the dynamic task. Exertion related more strongly to MHT than pain in both tasks. Neither gender nor activity level appeared to influence perceptual ratings, but peak torque explained approximately 20% of the variance in MHT.

Keywords

muscle fatigue; discomfort; isometric; isokinetic

1. Introduction

Musculoskeletal disorders (MSDs) are a leading cause of work-related disability and loss of productivity in industrialized countries (Panel on Musculoskeletal Disorders and the Workplace, 2001, Straaton, et al., 1998). The associated medical expenses and compensations pose a great socioeconomic burden, not to mention the compromised health and wellness in workers (Baldwin, 2004). MSDs are often associated with exposure to work-related physical risk factors such as forceful exertions, highly repetitive motions, prolonged static postures, awkward postures, and muscle fatigue (Bernard, 1997, Granata and Gottipati, 2008, Nussbaum, 2003, Punnett and Wegman, 2004).

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Minimizing worker discomfort is one approach that may reduce MSD risk (Dul, et al., 1994, Kee and Karwowski, 2001) as task exertion is related to workload (Borg, et al., 1985). This indirect assessment method is practical in workplace settings where direct measures of joint loads are infeasible. However, as muscles fatigue, discomfort increases despite no change in absolute workload. Maximum holding time (MHT) is one measure of task difficulty and tolerance that has been applied extensively in ergonomics to assess how long workers may endure a given task. Indeed, as intensity increases, MHT decreases exponentially (El ahrache, et al., 2006, Rohmert, 1960).

The direct assessment of MHT can be demanding and often impractical in both workplace and research settings. Instead, using perceptual discomfort ratings to predict MHT, and the development of fatigue, has been used as a surrogate measure (Douwes, et al., 2003, Van der Grinten and Smitt, 1992). This approach assumes that discomfort increases linearly over time and reaches a maximum at the time of task failure, following a ratio of 1 unit change in perceived discomfort per every 10% interval in total task time (%MHT). For example, a perceived discomfort rating of “5” (0 – 10 scale) would suggest the current working time is 50% of total MHT (Douwes, et al., 2003, Van der Grinten and Smitt, 1992), a “2” would indicate being at 20% of MHT (Miedema, et al., 1995), and so on.

Discomfort has been broadly defined to include perceptions of muscle “tension, fatigue, soreness, heat, tremor, and pain” (Van der Grinten and Smitt, 1992). This definition incorporates assessments of both perceived exertion (fatigue, heat, and tension) and perceived pain (soreness and pain), which are not fully independent. It has not been previously assessed if one aspect of discomfort, e.g. perceived exertion, is more predictive of MHT than another, e.g. pain.

Although the assessment of perceived pain/discomfort has been used to predict MHT for intermittent static tasks (Douwes, et al., 2003), its validity has been based predominantly on sustained static contraction data (Dul, et al., 1994, Mathiassen and Winkel, 1992). Furthermore, it is not known whether this linear ratio between MHT and perceived discomfort is valid during dynamic tasks.

Because there are increasing reports of MSDs involving the shoulder and the upper extremity (Sommerich and Hughes, 2006, Sommerich, et al., 1993), the primary purpose of this study was to determine the predictive values of perceived pain (focusing on localized discomfort, soreness/pain components) and perceived exertion on MHT during controlled submaximal static and dynamic tasks using the elbow joint. These two tasks approximately simulate common workplace duties requiring either a prolonged static holding posture, such as holding a box for an extended period, or repetitive motions, such as repetitively lifting an object during manual materials handling. We hypothesized that both pain and exertion would be linearly related to percent MHT (%MHT) for static and dynamic contractions. A secondary goal was to determine if gender and physical activity influenced either perceived pain or exertion during fatigue. We hypothesized that women would report greater pain but similar exertion based on a previous study using cycle ergometry (Cook, et al., 1997). We further hypothesized that the relationship between perceived exertion and MHT may be influenced by activity level, e.g. sedentary office work vs. heavy labor. A better understanding of the relationship between components of discomfort, particularly perceived exertion and pain, during fatiguing static and dynamic tasks could benefit the monitoring of fatigue and the prediction of MHT in workplace settings.

2. Methods

2.1. Participants

This investigation involved two studies: the first evaluating an isometric (referred to as static) fatigue task and the second an isokinetic (dynamic) fatigue task. Convenience samples of healthy young adults were recruited through advertisements placed on a University campus and its surrounding community to participate in either the static or dynamic fatigue study. Participants included undergraduate and graduate students, some with part-time employment, and non-students from the community (mix of occupations not specifically assessed). Written informed consent, as approved by The University of Iowa's Institutional Review Board, was obtained prior to all testing. Exclusionary criteria included: history of a serious medical condition (e.g., cardiovascular, pulmonary, or neuromuscular disease); history of a musculoskeletal injury/disorder of the non-dominant upper extremity (surgery, muscular rupture, rotator cuff tear, adhesive capsulitis); current report of pain; history of chronic pain; restriction from physical activity; highly trained individuals (e.g., marathon runners); pregnancy; inability to communicate verbally; or inability to transfer to the testing chair.

2.2. Procedures

The fatigue protocols were performed on an isokinetic dynamometer (Biodex System 3, Shirley, NY) using the nondominant arm. The nondominant arm was chosen to minimize any possible, subsequent delayed-onset muscle soreness from impacting normal upper extremity function. Participants were seated in the dynamometer chair, with the trunk and upper arm secured firmly with Velcro straps to minimize changes in posture during the task. The center of rotation of the dynamometer was aligned with the lateral epicondyle of the elbow joint, with the forearm supinated, and the hand gripping the dynamometer handle. The static and dynamic fatigue tasks were chosen to induce fatigue in similar muscles, primarily the elbow flexors, for a relatively similar duration, while using two different types of contractions and are described in more detail below. An uninformed maximum of five minutes was imposed for all subjects due to data collection limitations.

2.2.1. Static fatigue task—To determine each participant's relative submaximal target intensity, maximum voluntary contractions (MVCs, in Newton*meters, Nm) were assessed using three maximal isometric contractions of the elbow flexors (5 sec holds, 60 sec rests). The elbow was positioned at 60° of flexion, the shoulder positioned at approximately 30° of flexion, and the hand was supinated. After a 5 min rest, participants were asked to maintain isometric elbow flexion torque at 50% MVC (60° flexion) until failure. Participants received strong verbal encouragement and continuous visual feedback of their performance, including their current torque relative to the target torque on a computer screen positioned directly in front of the subjects. Participants were instructed to match the target torque for as long as they were capable. Maximum endurance time was characterized as the time (seconds) when the subjects were no longer able to steadily maintain torque within 15% of the target level, operationally defined as three consecutive drops in joint torque in 30 sec with verbal prompts from the investigator to return to baseline and/or when the participant requested to stop due to fatigue.

Participants rated their perceived exertion and pain intensity (0 to 10 ratings) during the fatigue task using the Borg category-ratio scale (Borg CR10) verbal numeric rating scale every 20 sec during the sustained isometric task. The Borg CR10 (Borg, 1998) is a validated self-report measure of perceived exertion or pain, with categorical anchors ranging from 0 (nothing at all, no pain or exertion) to 10 (extremely strong; max pain or exertion). Ratings higher than “10” are also possible if a sensation is perceived as greater than ever imagined, eliminating a ceiling effect.

2.2.2. Dynamic fatigue task—To provide a controlled dynamic fatigue task, a concentric isokinetic test protocol was used. Pilot testing revealed 50% MVC dynamic tasks resulted in dramatically longer endurance times than the previous static fatigue task. Thus, a higher intensity (75% MVC) was chosen to more closely approximate the endurance times of the two tasks. The dynamic MVC (in Nm) for elbow flexion was determined from three maximum isokinetic (constant velocity) contractions at 60°/sec, through a range of motion from 0° to 120° of elbow flexion. After 5 min in rest, the 75% submaximal dynamic fatigue task was initiated, involving alternating flexion and extension movements throughout the 120° range of motion. The task focused on the flexion portion of the movement – with visual and verbal feedback for subjects to achieve 75% of maximum dynamic flexion torque each contraction. Subjects produced sufficient elbow extension torque to return the dynamometer arm to the start position of the subsequent flexion movement in a continuous manner. Maximum endurance time was characterized as the time (seconds) when the subjects were no longer able to reach within 15% of their target goal (elbow flexion) for three consecutive flexion trials. Perceived pain and exertion were assessed verbally every 20th contraction (approximately 60 - 80 sec intervals), beginning with the 10th contraction, throughout the dynamic task using the Borg CR10 scale.

2.2.3. Activity questionnaire—All participants completed the International Physical Activity Questionnaire (IPAQ), prior to the fatigue task. The IPAQ (Booth, 2000) is a 27-item self-report measure of physical activity during the previous 7 days. Importantly, the IPAQ assesses both moderate and vigorous activities and measures physical activity across a comprehensive range of domains (i.e., work-related, leisure-time, domestic and garden work, and active transportation). It estimates the total activity performed in a week period as the intensity in metabolic equivalents (MET) multiplied by minutes (MET*min). This approach enables the IPAQ to assess overall levels of physical activity, not just exercise or sport-related activity. Overall, the IPAQ is a reliable measure, with 3-7 day test-retest reliability of 0.80 (Craig, et al., 2003). When compared to accelerometer data, the IPAQ has a low to strong median criterion validity (e.g. ranging from 0.30 (Craig, et al., 2003) to 0.67 (Hagstromer, et al., 2006)). However, this is comparable to many other established self-report physical activity instruments (Craig, et al., 2003, Sallis and Saelens, 2000).

2.3. Statistical analyses

Ratings of pain and perceived exertion were extracted at 25%, 50%, 75% and 100% of MHT for each subject. When endurance time quartiles did not exactly coincide with rating assessment times, the nearest available time was used. Descriptive statistics (mean, median, SD) were calculated for all pain, exertion, and IPAQ variables. Two-way analysis of variance (ANOVA) techniques were used to assess for significant differences in each variable between fatigue tasks (static vs. dynamic) and by sex. Effect sizes (Cohen's *d*) for gender and task differences were calculated as the mean difference standardized by the pooled standard deviation (Cohen, 1988). Effect sizes of 0.2 to 0.3, 0.5 and 0.8 to 1.0 have been suggested as small, medium, and large effect sizes, respectively (Cohen, 1988). A small effect size that is significant may have little practical relevance, whereas a large effect size that produces a non-significant difference could be meaningful as it may indicate an underpowered sample. Thus, this study was initially designed to be powered to detect moderately large effect sizes. Histograms of the frequency of pain and exertion ratings in unit measure bins were determined for each endurance time quartile. Pearson correlation coefficients were calculated between task time, pain, exertion, and activity level (IPAQ) at each endurance time quartile (25%, 50%, 75% and 100% MHT). Based on the smaller sample size of the dynamic task, correlations of 0.33 or greater could achieve statistical significance, and thus was used as the criterion value for both tasks. Simple linear regression techniques were used to determine the best linear relationship between task quartiles (% MHT) and pain or exertion ratings. Secondary analyses included correlational

analyses between MHT and peak torque for both tasks. Mean and standard deviations (SD) are reported throughout the text. Significance was set at $\alpha = 0.05$ for all analyses.

3. Results

3.1 Participants

Forty-two subjects completed the isometric elbow fatigue task (23 F, 19 M, age range 19 – 31 years) and 34 subjects completed the isokinetic, concentric elbow fatigue task (22 F, 12 M; age range 20 – 29 years). Two participants completed both fatigue tasks, separated by several months. Mean subject characteristics for individuals involved in each study are displayed in Table 1, including self-reported activity levels. Men were significantly heavier than women across both study cohorts and were on average one year older in the static fatigue task (see Table 1). No differences in self-reported activity levels were observed between men and women or between groups.

3.2 Maximum holding time (MHT)

Maximum holding time, averaged across men and women, was significantly longer for the dynamic, 331.9 (212.6) s, than the static task, 117.3 (42.9) s, ($F_{1,72} = 35.5$, $p < 0.0001$; $d = 1.5$) despite the higher relative intensity (Table 1). At task failure, the static task had significantly higher perceptual ratings than the dynamic task for pain ($F_{1,72} = 16.9$, $p < 0.001$; $d = 1.0$) and exertion ($F_{1,72} = 10.0$, $p = 0.002$; $d = 0.8$). Women were able to sustain both tasks longer than men ($F_{1,72} = 10.9$, $p = 0.002$), with relatively large effect sizes observed for the dynamic ($d = 0.9$) and the static ($d = 1.1$) tasks. However, despite these differences in task duration between sexes, peak pain ($F_{1,72} = 0.40$, $p = 0.53$) and exertion ($F_{1,72} = 0.39$, $p = 0.53$) ratings did not vary significantly between men and women.

3.3 Physical activity

Self-reported physical activity (IPAQ) scores were not significantly correlated to any ratings of exertion or pain throughout either fatigue task (range $r = -0.15$ to 0.20 , $p > 0.15$), nor with % MHT (range $r = -0.04$ to 0.22 , $p > 0.15$). Thus gender and activity level were not included in the remaining analyses due to their general lack of association with the primary outcome variables.

3.5 Ratings versus MHT

The relationships between pain and exertion ratings and the relative task duration (%MHT) are shown in Figure 1 for group means (panels A and C) and for individuals (panels B and D). Note the discrepancies between the previously described linear relationship between ratings and MHT (identity line) and the observed linear relationship. For the static task, group mean pain and exertion ratings increased linearly with each MHT quartile ($R^2 = 0.99$ each, Fig 1A). However mean pain ratings most closely approximated the 1:10% relationship between ratings and % MHT initially ($< 40\%$ MHT) whereas exertion ratings better matched the expected 1:10% relationship above 40% MHT. For example, a mean rating of “5” occurred at 41.9% MHT for exertion but not until 68.8% MHT for pain. Note the wide inter-individual variation in ratings for both pain and exertion (Figure 1B).

Group mean ratings for the dynamic task were only somewhat less linearly related to % MHT than the static task ($R^2 = 0.91$ each, Fig 1C). However, the regression slopes were steeper, and the total range of values narrower, such that mean pain and exertion ratings widely diverged from the 1:10% linear ratio. For example, exertion ratings reached a value of “5” earlier at 34.5% MHT but then were less than “8” at 100% MHT. Similarly, pain ratings never achieved a level of “5” at 100% MHT. Exertion proved to approach the 1:10% rating: MHT ratio more

closely than did pain. The individual ratings (Figure 1D) further indicate a poorer fit between pain and %MHT than between exertion and %MHT, although neither are particularly notable.

Although perceptual ratings increased with time for both tasks, the dynamic ratings changed less in the last quartile than in the first two. For the static task, pain and exertion ratings increased relatively evenly, by approximately 1.6 units each quartile (Figure 1A). During the dynamic task (Figure 1C), ratings of pain and exertion increased rapidly from 25 to 50% MHT (1.1 and 1.8 units for pain and exertion, respectively) but insignificantly from 75 to 100% MHT (0.1 and 0.3 units, respectively).

3.6 Peak torque versus MHT

Women demonstrated longer endurance times than men for the static and dynamic tasks (see Table 1). Secondary analyses revealed peak torque of the elbow flexors was significantly related to endurance time for both tasks, explaining approximately 20% of the variance in MHT (Figure 2).

4. Discussion

This study is the first to analyze the relative value of components of discomfort: pain and exertion, for predicting maximum holding time. Exertion ratings more closely followed the previously reported 1 to 10% ratio for rating to %MHT expectations than did pain ratings: e.g. “2” is equivalent to 20%MHT, “5” - 50% MHT, etc. No influence of gender or activity level was apparent. Further, both pain and exertion were better indicators of %MHT during the static than during the dynamic fatigue tasks. Thus, only a portion of our initial hypotheses were supported by our findings. These results may have important implications for estimating MHT during functional workplace tasks as repetitive or dynamic tasks are more likely to occur in the workplace than true, sustained isometric tasks without rest periods.

4.1 Associations between ratings and MHT

Although perceived task discomfort has been used as a measure of remaining task endurance time (Douwes, et al., 2003, Dul, et al., 1994, Miedema, et al., 1995), relatively little research has validated its use, particularly with dynamic tasks. Several authors have reported a significant correlation between localized pain and/or discomfort and % MHT during static tasks, consistent with our observations (Corlett and Manenica, 1980, Douwes, et al., 2003, Dul, et al., 1994, Rose, et al., 2000). However, using functional static postures at low task intensities, exertion and %MHT were highly nonlinear, increasing rapidly initially (Reneman, et al., 2001). These findings are consistent with our observations during the dynamic task.

Similarly, when studying the relationship between dynamic task intensity and perceived exertion in the absence of fatigue, Pincivero and colleagues found that perceived exertion under-predicted dynamic task intensity at higher intensities (Pincivero, et al., 2001). This is in line with our results, in which perceived exertion and pain ratings plateau as the dynamic task persists, suggesting ratings may under-represent task intensity as fatigue develops (e.g. akin to a higher relative task intensity) and/or over-predict MHT. It is not clear what mechanisms may explain why perceived exertion changes less in the final third of the dynamic task, thus warranting future research on this phenomenon.

4.2 Static vs. dynamic task comparisons

Participants were able to perform the dynamic task longer, while perceiving less pain or exertion even at task failure, despite working at a higher relative intensity. These findings may be explained by contraction-induced ischemia during the static contraction, which leads to hypoxia, higher local muscle lactate concentration, and ultimately greater fatigue development

(Enoka and Duchateau, 2008, Poole, et al., 1988, Sjogaard, et al., 1988). A local acidic environment stimulates muscle nociceptors, causing deep aching muscle pain (Frey Law, et al., 2008, Shah, et al., 2005). Thus, nociceptor activation likely occurs more during static tasks than dynamic or intermittent tasks. Repetitive or dynamic contractions provide a period of “relative rest,” likely allowing greater blood perfusion to muscles, and thus less pain with longer MHTs. Accordingly, pain ratings differed between the static and dynamic tasks more than exertion ratings in overall magnitude. Peak pain in particular was lower for the dynamic task, suggesting differences in ischemia between tasks may influence pain perception to a greater extent than perceived exertion.

While many tasks in the workplace involve sustained static contractions, a great portion of tasks are dynamic or intermittent in nature as motion, pauses, and breaks are an inherent part of work. Dynamic or intermittent-static tasks allow for blood reperfusion that may not be possible during a sustained static contraction. Predicting dynamic or intermittent-static task fatigue is considerably more complex than predicting sustained-static task fatigue. Unfortunately, the use of self-reported task perceptions appears to be substantially weaker for predicting dynamic task fatigue than static task fatigue. Future studies are warranted to examine whether perceptual ratings correlate with intermittent static contractions, considering the potential influences of cycle time and duty cycle.

4.3 Observed sex differences in fatigue

Women demonstrated significantly longer endurance times than men for these relative intensity tasks, consistent with previous research at the elbow (Hunter, et al., 2004, Hunter and Enoka, 2001) and shoulder (Nie, et al., 2007). Although pain sensitivity may be greater in women for some conditions (Greenspan, et al., 2007), no differences were observed in perceived pain between men and women during fatigue in the present study. Both higher pain with similar levels of exertion (Cook, et al., 1997) and similar pain and exertion between females and males have been reported previously (Nie, et al., 2007, Pincivero, et al., 2003, Pincivero, et al., 2001). These findings suggest that the critical variable influencing pain and perceived exertion during tasks is not absolute task duration (which varies between men and women), but rather the relative development of fatigue, effectively eliminating the gender difference.

When further examining the observed sex-differences in MHT, peak torque explained roughly 20% of the total variance in endurance times. Men typically produced greater peak torques for both tasks, and correspondingly were less able to sustain the tasks. Similar negative associations between peak torque and MHT have been observed at the elbow (Avin, et al., in press, Hunter and Enoka, 2001), but not at the ankle (Avin, et al., in press). Thus, greater peak torque results in a reduced ability to sustain a relative intensity task. However greater strength may result in reduced fatigue (e.g. longer task duration) for a task involving an absolute workload (and thus reduced relative workload) (Hamberg-van Reenen, et al., 2009). Even so, peak torque is a contributing factor to the observed sex-differences in MHT, but is not able to fully explain the phenomenon.

4.4 Discomfort components: pain versus exertion

Although discomfort is inherently comprised of sensations of pain and exertion, perceived exertion appears to be more closely related to MHT regardless of the nature of the task. The linear relationship between perceived exertion and task intensity has been well established in whole body exercises (Crewe, et al., 2008, Garcin, et al., 1998, Horstman, et al., 1979, Hunter, et al., 2009, Pincivero and Gear, 2000). Indeed, Borg suggests that perceived exertion correlates with objective physiological indicators (i.e., heart rate, blood lactate) more than pain does (Borg, et al., 1985). Further, perceived pain was more variable between individuals than perceived exertion for these isolated tasks (wider spread in individual ratings), consistent with

Borg's observations during cycle ergometry (Borg, et al., 1985). The greater variability in pain ratings relative to exertion may be in part due to greater individual differences in pain perception, as has been demonstrated with experimental pain testing in humans (Fillingim, 2005).

4.5 Potential study limitations

Several study limitations may limit the ability to generalize these findings. As two cohorts of young, healthy adults were used in this study, potential for between group differences may confound the results. Additionally, the mean self-reported physical activity levels (IPAQ) for both the static and dynamic groups were in the previously defined “highly active” category (Ishikawa-Takata, et al., 2008). As a result, our findings may not fully generalize to older, less motivated or inactive populations. Further, it is possible that the relationships between perceptual ratings and MHT could vary with task training, and accordingly by occupation. These findings do not address any occupation-specific assessments. While we attempted to approximately match MHT and task difficulty between the static and dynamic tasks, inherent differences remained. Although the dynamic task utilized a higher relative intensity (75% vs 50% of each task's peak torque), the perceived exertions for the isokinetic task were initially similar to the static task (see 25% MHT histogram), albeit pain was much less. Using a similar relative intensity for the dynamic task (e.g. 50%) would have resulted in even greater perceived differences between the two task workloads.

This study investigated only acute muscle pain/discomfort with fatigue, not musculoskeletal injury, repetitive trauma, or delayed onset muscle soreness (DOMS) that is also common with physical activity. However, these additional pain perceptions are not typically used to assess non-pathological levels of fatigue. Lastly, this study involved one joint, the elbow, which may not fully translate to larger muscle groups or the lower extremities.

5. Conclusions

This study demonstrates that perceived exertion is generally superior to pain perception for predicting endurance time for tasks of different natures. Thus, when assessing discomfort, care should be taken to instruct subjects to consider exertion as a component of discomfort. Further the expected 1:10% relationship between perceptual ratings and %MHT (e.g. that a rating of “5” corresponds to 50% MHT) is reasonably accurate for sustained static tasks, but questionable for dynamic tasks. In addition, the use of perceptual ratings as an indicator of fatigue and/or MHT is most valid for mean group behavior, but its use should be cautioned when trying to interpret a single individual's rating. Gender and self-reported activity levels did not significantly influence these relationships, although absolute endurance time was greater in women, mediated in part by peak strength.

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Figure 1. Perceptions vs. Task Duration

Static (A, B) and dynamic (C, D) task self-reported pain (filled circles) and exertion (open triangles) ratings at each relative task duration quartile (% maximum holding time, %MHT) for group means (SD) (A,C) and individuals (B,D). The best fit linear regression curves are shown: dashed for pain ratings, solid for exertion. The gray identity line (A, C) indicates the predicted 1:10% ratio of ratings to %MHT; note the relationship between each linear regression curve and this gray reference line.

Figure 2. Peak Torque vs. Task Duration

The relationships between peak torque and maximum holding time (MHT) are shown for the static (A) and dynamic (B) tasks, with males (filled circles) and females (open triangles) indicated. The best fit linear relationships between variables are shown.

Table 1

Mean (SD) subject characteristics for the study cohorts.

	Static Task			Dynamic Task		
	Male (n=19)	Female (n=23)	All (n=42)	Male (n=12)	Female (n=22)	All (n=34)
Age (yr)	24.3 [†] (3.2)	22.7 [†] (1.9)	23.4 (2.6)	24.1 (2.9)	23.2 (1.9)	23.5 (2.3)
Mass (kg)	81.3 [†] (10.1)	61.1 [†] (8.4)	70.4 (13.7)	85.7 [†] (14.4)	66.4 [†] (11.2)	73.3 (15.4)
MHT (sec)	93.7 [†] (34.1)	136.7 [†] (40.1)	115.8 [*] (42.6)	222.3 [†] (200.2)	391.6 [†] (198.6)	331.9 [*] (212.6)
Peak Torque (Nm)	74.2 (17.7)	34.9 (6.9)	52.7 [*] (23.6)	52.4 (8.2)	29.1 (8.0)	37.3 [*] (13.8)
Peak Pain (Borg CR10)	6.2 (2.6)	7.4 (2.4)	6.9 [*] (2.6)	4.3 (2.7)	4.0 (3.1)	4.2 [*] (2.9)
Peak Exertion (Borg CR10)	8.7 (1.5)	8.8 (1.2)	8.6 [*] (1.4)	7.8 (1.5)	7.3 (1.9)	7.5 [*] (1.8)
IPAQ total (MET*min)	3359 (2207)	3039 (2132)	3180 (2144)	3092 (2191)	3585 (2196)	3411 (2174)
IPAQ leisure (MET*min)	1681 (1912)	1254 (1032)	1442 (1479)	2068 (1880)	1963 (1197)	2000 (1447)

[†] Significantly different between M and F in each cohort; $p < 0.05$

^{*} Significantly different between static and dynamic tasks; $p < 0.05$

Note: MHT = Maximum Holding Time; IPAQ = International Physical Activity Questionnaire; MET = metabolic equivalent.