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The influence of occupation and age on maximal and rapid lower extremity strength

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ABSTRACT

The aims of this study were to 1) examine the influence of age and occupation on maximal and rapid strength of the lower-extremity muscles and 2) examine the relationship between maximal and rapid strength and physical workload (work index (WI)) in the blue-collar (BC) cohort. Peak torque (PT) and peak rate of torque development (peakRTD) of the leg extensors (LE), leg flexors (LF), and plantar flexors (PF) were assessed in 47 young (age = 24.1 ± 2.4 years) and 41 middle-aged (52.4 ± 5.2 years) white-collar (WC) and BC men. Middle-aged workers exhibited lower PT for all muscles, and peakRTD for the LF and PF muscles. A positive relationship ($r = 0.59$; $P < 0.01$) was observed between WI and peakRTD for the PF in the young BC workers, however, this relationship was negative ($r = -0.45$; $P = 0.053$) for the LF of the middle-aged BC workers. Lowering physical work demands and/or incorporating effective health-related practices for employees may be appealing strategies to enhance aging workers' productivity and longevity in the workforce.

1. Introduction

The rapidly rising age of the labor force has resulted in the number of workers aged 55 and older to double between 1990 and 2010, with projections of a further 38% increase by 2020 when this population will comprise 25% of the total labor force (Toossi, 2012). Despite recent technological advances and automated labor, workers categorized in blue collar occupations still comprise over 60% of the labor force (Workers by occupational category, 2012). In addition, the physical work demands of these workers may not decline with age (Ilmarinen, 2002), but may actually increase, as reported by Nygard et al. (1997) who examined physical work demands over an 11-year period in older workers. Moreover, research suggests that those involved in physically demanding work are predisposed to early retirement (Yeatts et al., 2000). Thus, a better knowledge of the influence of physical work demands on various physiological systems (e.g. neuromuscular function) will be important to help maximize the productivity and longevity of the aging manual laborer.

It is known that neuromuscular function progressively declines with advancing age (Clark and Manini, 2008) and adequate neuromuscular functioning is required for optimal occupational-related performance (de Zwart et al., 1995). Previous authors have also indicated that occupational demands may also have a significant influence on neuromuscular function. For example, studies examining the shoulder and wrist flexor muscles (Schibye et al., 2001; Tammelin et al., 2002; Torgen et al., 1999) have reported that workers in blue collar (BC) occupations exhibited greater muscular strength when compared to those in white collar (WC) occupations, while more studies have suggested either no differences for trunk and wrist flexor muscles (Nygard et al., 1987a, 1988, 1991a) or lower muscular strength for the wrist flexor, trunk, and leg extensor muscles (Nygard et al., 1987a, 1991a; Era et al., 1992; Heikkinen et al., 1984) for BC versus WC workers. Moreover, the interaction of the workers' age and occupational category further complicates the ability to elucidate the influence of occupational demands on the decline of overall physical function in the aging worker. Mixed findings have also been reported for the effects of aging in workers of different occupational categories. For instance, Schibye et al. (2001) demonstrated greater muscular strength in the

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shoulder muscles of BC workers (waste collection) when compared to WC controls, however, in contrast, both Heikkinen et al. (1984) and Era et al. (1992) reported lower strength in older BC workers compared to WC controls. Although discrepancies among these studies may be due to different strength testing methodologies, muscle groups, and age groups, little is presently known regarding the influence of physically strenuous work on neuromuscular function across the lifespan. A useful approach for enhanced clarification of such issues, would be to examine the relationships between occupational physical workload levels and muscle function at different stages in the working lifespan.

Although work-related neuromuscular function is most commonly assessed using maximal strength capacities, the ability to produce strength rapidly is often considered a more functionally relevant expression of strength (i.e. explosive or rapid strength) (Thompson et al., 2013a). Previous studies (Bento et al., 2010; Thompson et al., 2013b) have shown that the ability to rapidly produce torque is associated with athletic status and risk of falls, and thus may provide more sensitive physiological information regarding one's neuromuscular capacities compared to maximal strength alone. However, we are aware of no studies that have examined these variables among workers of different occupational categories. Furthermore, the majority of studies examining neuromuscular function in workers have focused on muscles of the upper body (i.e. trunk, shoulder, wrist muscles). However, the lower body musculature provides the primary means of locomotion, and the base of support for manual materials handling, with work abilities and injury risks being inherently linked to a workers' ability to move their body rapidly and efficiently. For instance, the most preventable fatal occupational-related events include contact with objects, and falls (Bureau of Labor Statistics, 2013). It is possible that the inability to rapidly produce torque may increase the likelihood of sustaining these injuries. Therefore, the purpose of the present study was to examine the influence of age and occupational category on maximal and rapid strength capacities in young and middle-aged BC and WC workers, with a secondary aim to investigate the relationship between physical workload and maximal and rapid strength in the BC cohort. In light of previous literature, it was hypothesized that BC workers would exhibit similar age-related declines in strength capacities compared to WC workers, and that higher workload would be related to lower strength-related performance in BC workers.

2. Methods

2.1. Participants

Twenty-two young WC (mean ± SD: age = 25.0 ± 2.9, stature = 177.4 ± 7.1, mass = 84.7 ± 11.7), twenty-five young BC (age = 23.1 ± 1.8, stature = 174.9 ± 6.1, mass = 87.5 ± 21.4), twenty-two middle-aged WC (age = 51.8 ± 5.0, stature = 181.0 ± 7.4, mass = 98.6 ± 17.3) and nineteen middle-aged BC (age = 53.0 ± 5.4, stature = 175.8 ± 7.9, mass 97.3 ± 15.6) working men volunteered to participate in the study. The participants were recruited from communities near the University by advertisement flyers, direct mailings, telephone and in person contact. This study was approved by the University Institutional Review Board and all participants completed and signed an informed consent document and health history questionnaire. The health history questionnaire was used to screen participants for study participation. Participants were required to be apparently healthy, with no contraindications to physical exercise. None of the participants reported having a myocardial infarction event nor any current or ongoing neuromuscular diseases or musculoskeletal injuries of the ankle, knee, or hip of their right leg within 1 year prior to testing.

2.2. Procedures

Participants visited the laboratory on three separate occasions with the first session being a familiarization trial where the participants completed a health history and modified Baecke questionnaire, had all anthropometric measurements recorded, and then performed a minimum of three practice isometric maximal voluntary contractions (MVCs) for the plantar flexors (PF), leg extensors (LE), and leg flexors (LF). Within two–four days following the familiarization trial, participants reported back to the laboratory for the first experimental trial which involved isometric strength testing of the PF, followed by the isometric strength assessments of both the LE and LF muscle groups four–seven days later with all testing conducted at the same time of day (±2 h).

2.3. Occupational classification and work index

Occupational information including work history (duration at the specified occupation), employment status (full or part time), and job description (type of tasks performed at work) were collected via questionnaire and interview format during the familiarization trial. Each participant's occupation was defined as the primary job that they performed the longest throughout the duration of their occupational or active life (Russo et al., 2006) for a minimum of 30 h per week. Participants were classified according to their occupation using a two category job classification system, where workers are grouped into broad categories based on similar types of occupations, in accordance with the procedures of previous studies (Russo et al., 2006; Almoosawi et al., 2012). The two categories consisted of either WC- or BC-related occupations. Specifically, WC workers included occupations categorized as managers, administrators, scientific or research professionals (i.e., professors, technicians, intellectuals), clerical employees, full-time students, and market or sales workers. BC workers included occupations categorized as skilled workers in agricultural, manufacturing, or construction industries, machine installers or operators, assemblers, mechanics, grounds crew and unskilled laborers. Participants were further categorized by age as being either young (19–29 years) or middle-aged (45–61 years). In addition, the young and middle-aged BC groups completed a series of occupational- and leisure-related questions from the modified Baecke physical activity questionnaire (Pols et al., 1995) (appendix questions 2–8 and 11–20, respectively) to determine their self-reported work index (WI) and leisure index (LI) scores.

2.4. Isometric maximal voluntary contractions

The MVC testing procedures have been described previously (Thompson et al., 2013a). Briefly, the MVCs were performed with the right leg using a calibrated Biodex System 4 isokinetic dynamometer (Biodex Medical Systems, Inc. Shirley, NY, USA). For all strength assessments, participants were seated with restraining straps placed over the trunk, pelvis, and thigh and the lever arm of the dynamometer was strapped to the lower leg via either a padded velcro strap at a level of 5 cm proximal to the lateral malleolus (LE and LF testing), or the foot was secured to a footplate with a thick rubber heel cup with straps placed over the toes and metatarsals (PF testing). The input axis of the dynamometer was aligned with the axis of rotation of the knee and ankle joints. All PF MVCs were performed at a neutral joint angle (90° between the leg and the foot) and at a leg angle of 60° below the horizontal plane for the LE and LF muscle actions (Thompson et al., 2013b). Prior to the maximal strength testing, participants performed a 5 min warm-up on a cycle ergometer (Monark Exercise 828E, Vansbro, Sweden) at a self-selected low-intensity workload. Following the warm-up,