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A cycling workstation to facilitate physical activity in office settings

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ABSTRACT

Facilitating physical activity during the workday may help desk-bound workers reduce risks associated with sedentary behavior. We 1) evaluated the efficacy of a cycling workstation to increase energy expenditure while performing a typing task and 2) fabricated a power measurement system to determine the accuracy and reliability of an exercise cycle. Ten individuals performed 10 min trials of sitting while typing (SIT_{type}) and pedaling while typing (PED_{type}). Expired gases were recorded and typing performance was assessed. Metabolic cost during PED_{type} was ~2.5× greater compared to SIT_{type} (255 ± 14 vs. 100 ± 11 kcal h^{-1}, $P < 0.01$). Typing time and number of typing errors did not differ between PED_{type} and SIT_{type} (7.7 ± 1.5 vs. 7.6 ± 1.6 min, $P = 0.51$, 3.3 ± 4.6 vs. 3.8 ± 2.7 errors, $P = 0.80$). The exercise cycle overestimated power by 14–138% compared to actual power but actual power was reliable ($r = 0.998$, $P < 0.01$). A cycling workstation can facilitate physical activity without compromising typing performance. The exercise cycle's inaccuracy could be misleading to users.

1. Introduction

Thirty-five percent of adults in the United States are currently obese and at increased risk of developing several metabolic, cardiovascular, and psychological disorders (Haskell et al., 2007; Mutrie, 2001). Health care costs attributed to obesity are approximated to be $147 billion per year in the United States and those costs are predicted to increase to $200 billion per year over the next two decades (Finkelstein et al., 2009). Obesity results from a long-term excess of energy consumed vs. energy expended, a positive energy balance (Church et al., 2011). While overeating certainly contributes to a positive energy balance, the epidemic of obesity and related metabolic disorders is also driven by reductions in energy expended (Ford et al., 2012). With increased use of computers, office workers may remain seated and sedentary (Barnes et al., 2012) during which energy expenditure is minimal, making many offices obesogenic environments (Mummery et al., 2005). Sedentary behavior not only contributes to positive energy balance but is also an independent risk factor for diabetes, cardiovascular disease, and all-cause mortality (Wilmot et al., 2012). Therefore, increasing physical activity and/or decreasing sedentary time are paramount to reducing obesity and associated disorders. However, traditional strategies to increase physical activity are compromised by insufficient time for exercise, perception that exercise is boring, concern about appearance during exercise, and fatigue after the workday (Mayo Clinic, 2011). These barriers could be reduced by facilitating physical activity during working hours.

Treadmill workstations have been promoted as means to increase physical activity during working hours. John et al. (2011) reported that office workers, provided with a treadmill workstation for nine months, increased their walking time by 38–75 min day^{-1}, compared to baseline, and averaged a walking speed of 1.5 mph. This duration and speed suggests an energy expenditure of approximately 100–200 kcal day^{-1}, above baseline (Levine and Miller, 2007). Compared to baseline, the participants in this study exhibited significant decreases in waist and hip circumference as well as improvements in blood lipids and cholesterol. Similarly, Koepp et al. (2013) recently reported that office workers who were provided with a treadmill workstation for one year increased physical activity and decreased weight, while maintaining productivity (Koepp et al., 2013). This finding of unchanged productivity is important because other authors have reported that use of a treadmill workstation may compromise computer use accuracy (Funk et al., 2012; John et al., 2009) and/or work productivity

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(Thompson and Levine, 2011). A potential limitation of treadmill workstation use is that individuals who are overweight and obese are at increased risk for knee osteoarthritis (Felson et al., 1988) and thus may have limited ability to walk.

As a non-weight bearing activity, cycling could serve as an alternative modality for facilitating increased physical activity in desk-bound office workers. Indeed, Straker et al. (2009) evaluated the effects of a cycling workstation (computer desk and an upright exercise cycle) on physiological responses and computer operation in office workers. Specifically, these authors reported that heart rate values increased by ~25% when pedaling and typing compared to normal sitting and typing. Additionally, these authors reported that typing performance while cycling was slightly compromised but was better than typing performance during treadmill walking. To the best of our knowledge, no previous authors have reported the actual rate of energy expenditure that individuals might self-select for pedaling during an office task such as typing. It is also important to note that the previous cycling workstation design used by Straker et al. (2009) consisted of an upright exercise cycle with a relatively small seat. This design may present some ergonomic challenges, especially when using it for extended durations, as several participants in that study (9 out of 30) reported some form of hip or gluteal discomfort related to the exercise cycle seat. Further, such bicycle seats are known to reduce penile oxygen pressure, reflecting perineal compression (Schwarzer et al., 2002) and prolonged sitting on such seats can lead to perineal numbness and erectile dysfunction (Dettori et al., 2004). Thus, a cycling workstation with a recumbent seat position that is more similar to a standard office chair may facilitate prolonged activity without risks associated with upright cycling.

Our primary purposes for conducting this investigation were to 1) determine the metabolic cost associated with self-selected pedaling intensity while performing a standardized typing task and 2) assess the influence of pedaling on typing performance (typing time and number of typing errors). These responses were compared to those associated with normal sitting while typing. We hypothesized that compared to sitting while typing, pedaling while typing would increase metabolic cost without compromising typing performance. Additionally, because the accuracy and reliability of commercial exercise cycles to quantify power are not documented, our secondary purposes were to 1) fabricate a power measurement system to determine the actual power associated with pedaling the exercise cycle across a range of resistance levels and pedaling rates before and after the experimental trials and 2) compare the actual power, as determined by the power measurement system, to the power displayed by the exercise cycle console. This study could serve as an important first step to utilizing a cycling workstation to reduce sedentary time and increase physical activity in office settings.

2. Methods

2.1. Participants

Ten healthy males volunteered to participate in this study (age: 32 ± 8 yr, body mass: 72 ± 8 kg, height: 1.78 ± 0.07 m, body mass index: 23 ± 2 kg m^{-2}). Participants were college students and faculty who spent considerable time sitting at a desk each day (6.3 ± 2.4 h day^{-1}, self-reported). Participants were also recreationally active in a variety of sports and familiar with cycling exercise (both upright and recumbent cycling positions). Experimental procedures used in this investigation were reviewed by the University of Utah Institutional Review Board. The protocol and procedures were explained verbally and all participants provided written informed consent prior to testing.

2.2. Experimental protocol

Participants reported to the laboratory dressed in typical school or office attire and were instructed to refrain from eating for at least 3 h prior to testing. During this visit resting baseline data were first recorded. Subsequently, participants performed two experimental trials (10 min) while physiological responses were recorded (described below):

1) Sitting while typing
2) Pedaling while typing

For the sitting while typing condition, participants were positioned on the cycling workstation (but did not pedal) and performed a standardized typing task (described below). For the pedaling condition, participants were positioned on the cycling workstation and pedaled while they performed the same standardized typing task. The two experimental trials were presented in a random order. At least 5 min of recovery was provided between each trial to allow physiological responses to return to baseline levels.

2.3. Typing task

To quantify typing performance, we measured the time required to transcribe the Gettysburg Address, a famous speech delivered by United States President Abraham Lincoln in 1863, which participants practiced typing twice prior to the experimental protocol. For this task, a copy of the Gettysburg Address was placed adjacent to the computer screen and participants were instructed to transcribe the Gettysburg Address at a comfortable typing speed, a speed at which they typically performed school and/or office-related typing. Participants were also instructed to correct any typing errors that might have occurred as they typed so that the overall quality of the document was equivalent to that of school and/or office work. Because all participants regularly used a word processing autocorrect spelling/grammar feature this setting was enabled during the standardized typing task. The total time required to transcribe the Gettysburg Address and correct any potential errors was recorded. In addition, an investigator carefully reviewed the document and recorded the actual number of typing errors. If participants completed the typing task before the 10 min period was over then they were simply asked to start the typing task again but the second round was not timed or completed.

2.4. Cycling workstation

A cycling workstation was constructed using a commercially available recumbent exercise cycle (Model R3i, LifeSpan Fitness, Salt Lake City, UT, USA), a set of adjustable height table legs (Model UpLift 700, The Human Solution, Austin, TX, USA), and a custom made keyboard tray with integrated arm support (Fig. 1). The seat pan of the exercise cycle was 44 cm wide, 26 cm deep, and positioned at an inclination of ~1° (positive to horizontal). The back support was 40 cm wide, 52 cm tall, and positioned at an inclination of ~15° (backward of vertical). The standard exercise cycle cranks (170 mm) were replaced with shorter cranks (114 mm, Unicycle.com) to facilitate usable ergonomics. Participants selected a seat position that allowed a slight bend at the knee when the leg was in its most extended position. The desk height was then adjusted to be as low as possible while still providing clearance for the knees during pedaling. The cutout in the keyboard tray was approximately 24 cm deep and 41 cm wide (Fig. 1). This depth allowed the tray to extend to the anterior-posterior midline of the torso and thus provide support for the elbows when the upper arm