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CURRENT OPINION

The Potential Yield of Non-Exercise Physical Activity Energy Expenditure in Public Health

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Abstract Previous work has shown prospective associations between total daily physical activity energy expenditure and various health outcomes including metabolic risk. Limited evidence is available on the health benefits of standing and light-intensity activity. Therefore, these behaviours are not supported in contemporary physical activity guidelines. Moreover, people may be more willing to replace sedentary activities with standing or light activities that can be incorporated into their daily lives, rather than activities of moderate intensity, as there are fewer potential barriers. With the rapid advancement of objective physical activity monitoring there is now potential to explore total daily physical activity energy expenditure in more depth. This article highlights the need for further research into all areas of total daily physical activity energy expenditure, in particular standing and light-intensity activities. Future physical activity guidelines may benefit from the inclusion of recommendations on physical activity energy expenditure rather than solely focusing on activities of a moderate or vigorous intensity.

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Key Points

Research is now emerging that suggests replacing sedentary time with standing or light intensity activity may aid in the prevention of major non-communicable disease risk factors.

We hypothesise that adherence to interventions that require participants to increase levels of non-exercise physical activity energy expenditure may be higher than those interventions involving only moderate-to-vigorous physical activity, owing to fewer potential barriers.

We should consider re-conceptualising public health physical activity guidelines to maximise the likelihood of shifting the largest proportion of currently sedentary individuals along the physical activity continuum to a higher physical activity category.

There is a need for research into all areas of physical activity energy expenditure, thus helping physical activity recommendations to continually evolve to reflect new knowledge.

1 Current Opinion

The purpose of the present paper is to encourage more research into all areas of physical activity (PA) energy expenditure (EE) in order to aid in development of future physical activity guidelines. The term PAEE may be defined as energy expended above that of the resting level.

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PAEE is usually calculated by subtracting resting EE from total EE. Previous work has shown prospective associations between PAEE and various health outcomes including metabolic risk [1, 2]. Interestingly, in a recent study, participants (aged 70–82 years) expending higher levels of PAEE did not report greater participation in structured forms of vigorous exercise, walking for exercise, and walking other than for exercise [2]. Traditional self-reported methods to assess PA capture structured forms of moderate-to-vigorous activities (MVPA; e.g., brisk walking, sports and exercise) but largely fail to detect lighter intensity activities, as they can be difficult to recall. As a result, light-intensity activity is not supported in contemporary PA guidelines, as we do not have data to support its inclusion. It has been hypothesised that increases in PAEE may have health benefits regardless of how that increase is achieved (i.e., achieved via short periods of MVPA or long periods of light-intensity activity that may yield equivalent levels of PAEE). With the rapid advancement of objective PA monitoring, there is now potential to explore PAEE in more depth to assess whether other parts of the PA continuum are beneficial for health. This article highlights the need for further research into all areas of PAEE, in particular, standing and light activities.

Contemporary data demonstrate the predominance of sedentary (e.g., sitting) lifestyles in western society. For example, objective data from general adult population studies in the United States and Great Britain [3] have shown that, on average, adults spend approximately 60–70 % of their waking hours in sedentary activities, 25–35 % in light-intensity activity, and, in a small proportion of people, the remainder is spent in MVPA. Self-reported sedentary behaviours have been consistently associated with risk of cardiovascular disease (CVD) in population cohort studies, although associations tend to be most marked in participants reporting low levels of MVPA [4]. In addition to CVD, emerging evidence suggests that time spent in sedentary activity is associated with certain cancers. For example, Boyle et al. [5] conducted a population-based case–control study and reported that participants that had worked 10 or more years in a sedentary occupation had almost twice the risk of distal colon cancer and 44 % increased risk of rectal cancer compared with participants that had not spent any time in sedentary work. The association was independent of leisure-time PA and the observation remained amongst the most recreationally active participants. Based on the concept of PAEE, displacing sedentary time with any type of 'movement' might therefore have desirable health effects. Such a strategy might not necessarily involve MVPA, as interventions to increase levels of such behaviours have proved challenging and largely unsuccessful; this is reflected in the low population levels of MVPA in westernised countries. For example, in a recent study of adults from 122 countries [6], approximately a third (31.1 %) were physically inactive (defined as not meeting PA recommendations). Instead, given the barriers to MVPA (e.g., motivation, cost, time and prohibitive physical environments), we might consider more subtle lifestyle approaches that are primarily designed to displace sitting with standing or light intensity PA, to increase PAEE. We define light-intensity activity from here on as being on the PAEE continuum between not moving (sitting or standing still) and moving at a moderate intensity (e.g., brisk walking) and within the range of 1.5–3 metabolic equivalents (METs).

It is reasonable to assume that interventions to increase levels of PAEE through standing or light activities (e.g., incidental movement) may be more successful than those that target only MVPA because westernised society promotes opportunities to be sedentary (i.e., screen-based entertainment, motorised transport) and many environments are prohibitive to MVPA. Thus, people may be more willing to replace sedentary activities with standing or light activities that can be incorporated into their daily lives, rather than activities of moderate intensity, as there are fewer potential barriers (e.g., motivation to undertake light activity typically requires lower cognitive effort and elicits less palpable physiological responses; money/equipment/facilities required to participate in some forms of MVPA, such as structured exercise). Potential interventions may involve restructuring the layout of buildings (e.g., shopping malls, offices) to promote movement (e.g., see Smith et al. [7]), encouraging active computer gaming over sedentary TV viewing, encouraging standing on public transport over sitting, and incorporating standing desks into the workplace, to list a few. If population activity patterns can be shifted from predominantly sedentary to standing or light activity, consequent interventions targeting MVPA may then be more successful as it reflects a more natural shift along the PA continuum.

There is a large body of literature that shows regular participation in MVPA is beneficial for a wide range of health outcomes. There is, however, limited data on the health benefits of increasing standing or light activities by reducing sedentary behaviour, which might be largely explained by the lack of robust research tools to assess these behaviours. In a recent population study of Canadian adults followed up over 12 years, self-reported standing time was inversely related to CVD mortality, although the association was only observed in the physically inactive participants [8]. Therefore, individuals who are not gaining the benefits of a physically active lifestyle may at least mitigate some of the health hazards associated with physical inactivity by standing more during the day. Recently, several small-scale experimental studies have emerged in this area. For example, in one study using continuously

monitored capillary blood glucose, there was a 43 % reduction in post-prandial blood glucose excursion during an afternoon (185 min) of standing compared with sitting in desk-based workers [9]. In a study that replaced sitting workstations with sit-stand workstations, employees reduced sitting time by 137 min/day and increases in HDL cholesterol (0.26 mmol/L; 95 % CI 0.10, 0.42) were observed at 3 months follow-up [10]. In a study of 19 overweight/obese adults sitting with 2-min bouts of light-intensity walking every 20 min was more beneficial for acute metabolic changes than uninterrupted sitting, and sitting with 2-min bouts of moderate intensity walking was more beneficial than the light-intensity walking condition [11]. The biological mechanisms underlying these effects still remain unclear, although increased muscle activation during standing could be an important underlying mechanism; for example, by increasing skeletal muscle metabolism. Replacing sitting workstations with sit-stand workstations has also been shown to increase PAEE [9], and increased PAEE has been linked to favourable metabolic health outcomes [2], as previously discussed. Taken together, chronic health benefits of replacing sitting with standing or light activities are biologically plausible as increases in PAEE are likely to have health benefits regardless of how that increase is achieved.

The limited evidence on health effects of replacing sitting with standing or light PA is predominantly due to limitations in the assessment of free living activity and in the way the continuum of physical activities has been previously conceptualised. Until recently, differentiating between sitting, standing and light activity have created difficulties in interpreting objective data. The most commonly used accelerometer, the Actigraph, quantifies time spent in different intensities of activity by summing time above and below specified count thresholds. This method works reasonably well for identifying activity intensity (i.e., sedentary, light, moderate, vigorous) but less accurate for identifying postural allocation (i.e., distinguishing between sitting versus standing). Thus, methods that employ postural allocation may be more reliable. Recently, combined accelerometer/inclinometers (such as the thigh worn ActivPal) that employ this postural allocation method have become available. The ActivPal is validated to estimate time in different postures (i.e., sitting and standing), step count, static and dynamic behaviours, and sitting-standing transitions, in adults [12]. In addition, new statistical approaches are emerging to better understand time reallocation effects of replacing one type of activity for another. This paradigm is designed to simultaneously model the specific activity being performed and the specific activity being displaced in an equal time-exchange fashion [13]. This type of modelling approach might be crucial to gaining a better understanding of the effects of displacing sedentary time with the next lowest category of PA.

In summary, research is now emerging that suggests replacing sedentary time with standing or light activity (i.e., increasing PAEE regardless of how that increase is achieved) may be an effective public health strategy in the prevention of major non-communicable diseases in adult populations. It is important to note the dose-response relationship between PAEE and health outcomes; any type of activity that increases energy expenditure is likely to be beneficial for health. For example, standing is likely to be more beneficial to health than sitting, walking is likely to have greater health benefits than standing, and jogging is likely to be better than walking. When consistent data have emerged we should consider re-conceptualising public health PA guidelines to maximise the likelihood of shifting the largest proportion of currently sedentary individuals along the PA continuum to a higher PA category where they may accrue numerous health benefits from increased PAEE. Indeed, if we are aiming to slow the trajectories (or perhaps reverse the trends) of non-communicable diseases such as CVD, then it is paramount that we try new PA health messages to shift large numbers of the general population in the positive direction along the PA continuum. Moreover, adherence to interventions that require participants to increase levels of 'non-exercise' PAEE is likely to be higher than those interventions involving only MVPA, owing to fewer potential barriers. In conclusion, there is a need for research into all areas of PAEE, thus helping PA recommendations to continually evolve to reflect modern-day society (e.g., a technology-driven lifestyle that promotes sedentary behaviour).

Conflicts of interest Lee Smith, Ulf Ekelund, and Mark Hamer declare that they have no conflicts of interest.

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