Université de Montréal

Le temps sédentaire au travail et les bureaux actifs
Compréhension des différences entre les bureaux actifs

par François Dupont

École de kinésiologie et des sciences de l'activité physique
Faculté de médecine

Mémoire présenté
en vue de l'obtention du grade de deuxième cycle
en sciences de l'activité physique

Octobre, 2019

Résumé

Dans nos pays industrialisés, les comportements sédentaires entrainent des enjeux de santé pour de nombreux travailleurs, les exigences physiques de leur travail étant désormais insuffisantes. Afin de répondre à cette problématique, la recherche s'intéresse aux bureaux actifs (poste de travail debout, avec pédalier ou avec tapis roulant) qui comparativement au poste de travail conventionnel permettent aux travailleurs d'augmenter l'apport d'activité physique au travail et ainsi, réduire le temps sédentaire quotidien. Lorsqu'ils sont comparés au poste conventionnel (assis), les bureaux actifs ont des effets sur des biomarqueurs physiologiques et biomécaniques liés à l'amélioration de la santé. En plus, ils offrent quelques avantages sur la productivité et le bien-être au travail des travailleurs. Malgré l'accumulation des connaissances sur les bureaux actifs, les différences entre bureaux actifs sont toujours méconnues. Ce mémoire s'adresse donc à la compréhension et à la comparaison entre les types de bureaux actifs, plus précisément à leurs impacts sur le temps sédentaire au travail, leurs effets sur les biomarqueurs physiologiques et biomécaniques et à leurs effets sur la productivité et le bien-être au travail. Pour ce faire, les résultats et la discussion sont développés autour d'un article de revue systématique (Dupont et al., 2019) et d'un article issu d'une recherche expérimentale soumis en octobre 2019. Dans un premier temps, les avantages associés à chaque type de poste de travail actif (debout, avec pédalier ou avec tapis roulant) ne sont pas équivalents. En effet, les postes avec pédalier et avec tapis roulant semblent apporter de plus grands changements physiologiques à court terme que les postes de travail debout et pourraient potentiellement améliorer la santé. De plus, les postes debout, avec pédalier et avec tapis roulants semblent tous présenter des avantages de productivité à court terme, toutefois les postes avec tapis roulants réduisent les performances des tâches faites à l'aide de clavier et de souris d'ordinateur. Dans un deuxième temps, à court terme (2 semaines), l'introduction d'un poste debout et d'un poste à pédalier dans leur bureau permet aux travailleurs d'accumuler en moyenne 132 minutes de temps actif (ex. travail fait avec poste debout et/ou avec poste avec pédalier) par jour, ce qui représente 46 % du temps total passé dans leur espace de travail personnel. Ce faisant, les travailleurs réduisent de moitié leur temps assis au travail en fractionnant le temps assis en courtes périodes de 30 minutes. Basé sur nos résultats, l'ajout de deux postes de travail actif à même le bureau d'un travailleur permet de diminuer le temps sédentaire au travail.

Mots-clés : bureaux actifs, sédentarité, santé et sécurité au travail

Abstract

In our industrialized countries, sedentary behaviours lead to health issues for many workers, as the physical demands of their work are now insufficient. To answer this problem, the research focuses on active workstations (standing, with pedals or treadmill workstations) which compared to the conventional workstation allow workers to increase physical load at work and thus, reduce daily sedentary time. When compared to the conventional (sit) workstation, active workstations have effects on physiological and biomechanical biomarkers related to better health. Also, they offer some advantages over workers' productivity and well-being at work. Despite the accumulation of knowledge about active workstations, the differences between active workstations are still unknown. This thesis is aimed at understanding and comparison between active workstation types, specifically their impacts on sedentary time at work, their effects on physiological and biomechanical biomarkers and their effects on productivity and well-being at work. The results and the discussion are developed around a systematic review article (Dupont et al., 2019) and an article from an experimental research submitted in October 2019. First of all, the benefits associated with each type of active workstation (i.e. standing, cycling, treadmill) may not be equivalent. Cycling and treadmill workstations appear to provide greater short-term physiologic changes than standing workstations that could potentially lead to better health. Cycling, treadmill and standing workstations appear to show short-term productivity benefits, while treadmill workstations reduce the performance of computer-related work. Secondly, in the short term (2 weeks), the introduction of a standing workstation and a pedal workstation in their office allows workers to accumulate an average of 132 minutes of active time (i.e. work done with standing and/or cycling workstations) per day, which represents 46% of the total time spent in their personal workspace. As a result, workers reduce their total desk-sitting time by half and sat on average 30 minutes per sedentary bout. Based on our findings, adding two active workstations to an office worker's helps reduce sedentary time at work.

Keywords: Active workstation, Sedentary, Occupational health

Table des matières

Liste des sigles

IMC. : Indice de masse corporel
MET. : Équivalent métabolique
PIB : produit intérieur brut
km/h : kilomètre par heure
W : watts

Remerciements

À ma directrice de recherche, Marie-Eve, pour m'avoir donné une chance, pour sa disponibilité et son support.

Aux collègues du laboratoire du LAPS, avec qui les conversations et les rires m'ont aidé à persévérer au travers de ces deux dernières années.

Aux fonds « Social Sciences and Humanities Research and Canadian Institutes of Health Research » et au « Fonds de recherche Québec-Santé » pour votre soutien financier.

À ma petite famille d'amour qui sont la source de toute mon énergie, Hugo, Anouk,
Antoine et Sophie

Introduction

Le mot sédentarité tient sa racine du mot latin *Sedere*, qui désigne le verbe s'asseoir ou être assis (DicoLatin©, 2012), référence historique qui s'avère toujours valable. Selon un large consensus scientifique, les activités sédentaires se caractérisent par une dépense énergétique de 1,0 à moins de 1,5 équivalent métabolique (MET) (Ainsworth et al., 2000) (Neville Owen, Healy, Matthews, & Dunstan, 2010; Pate, O'Neill, & Lobelo, 2008; Tremblay et al., 2017). Parmi les exemples communs de comportements sédentaires, on retrouve le travail assis devant l'ordinateur, la conduite de sa voiture pour aller et revenir du travail ou regarder la télévision (Neville Owen & Zhu, 2017). La définition de comportement sédentaire n'est pas à confondre avec une absence d'activité physique. En effet, il est également important de souligner qu'un individu qui respecte les recommandations mondiales pour l'activité physique peut également avoir un comportement sédentaire excessif (Salmon, Tremblay, Marshall, & Hume, 2011).

Les derniers recensements publiés par l'Organisation mondiale de la Santé (OMS) datent de 2008 et estiment que près de 28 % des hommes et 54 % des femmes âgées de 15 ans et plus sont sédentaires (pratique insuffisante d'activité physique). Toujours selon l'OMS, on mesure les plus hauts taux de comportements sédentaires dans les Amériques et dans les régions de la méditerranée orientale (près de 50 % pour les femmes et 40 % pour les hommes méditerranéens et 36 % pour les hommes vivant dans les Amériques). Au Canada, on estime que la population adulte passerait 77 % de son temps éveillé en temps sédentaire. Ce taux représente en moyenne 9,4 h/par jour (9,7 h/jour pour les hommes et 9,4 h/jour pour les femmes) (Agence de la santé publique du Canada, 2016).

L'excès de temps sédentaire a des coûts, principalement sur la santé et l'économie. En 2016, une étude a estimé qu'au niveau mondial, les coûts directs et indirects liés à la sédentarité seraient de 89 milliards de dollars canadiens. Ce coût représenterait 71 milliards de dollars en dépenses de santé et 18 milliards en perte de productivité. De façon sommaire, cette dépense représente pour les pays à haut revenu per capita entre 1 % et 4 % du produit intérieur brut (PIB). Ces pays riches assumeraient une plus grande proportion des coûts, soit 80 % des coûts de soins de santé et 60 % des coûts indirects (Ding et al., 2016). Au Canada, les coûts économiques dus au manque d'activité physique seraient, selon les différents modèles statistiques, entre 2,4 et 6,8 milliards de dollars, soit en moyenne 3,6 % du coût global en santé (Janssen, 2012).

Parmi les risques liés à la sédentarité, les personnes très sédentaires ont un risque 112 % plus élevé d'avoir du diabète de type 2 que les gens moins sédentaires (Biddle et al., 2015). De plus, une augmentation du risque relatif de 147 % des maladies cardio-vasculaires, une augmentation de 90 % du risque de mortalité cardio-vasculaire et une augmentation de 49 % du risque de mortalité toutes causes confondues sont associées à l'excès de comportements sédentaires (Wilmot et al., 2012). Moins élevé, mais aussi attribuable au comportement sédentaire, on observe une augmentation de 13 % du risque de mortalité tous types de cancers confondus (Neville Owen & Zhu, 2017). L'excès de temps sédentaire est aussi lié au risque de dépression et à la détérioration de la santé mentale, notamment par une augmentation de 25 % du risque de symptômes liés à la dépression (Zhai, Zhang, & Zhang, 2015). Finalement, l'excès de temps assis au travail et plus précisément au temps passé à l'ordinateur est lié aux troubles musculo-squelettiques et ce, même si l'utilisateur ne remarque pas de diminution de ses capacités cognitives (Baker, Coenen, Howie, Williamson, & Straker, 2018). Plusieurs auteurs relatent les problématiques suivantes : des douleurs au dos (lombaires, thoraciques et cervicales) et des tendinopathies au poignet et à la main (Baker et al., 2018; Ekman, Andersson, Hagberg, & Hjelm, 2000; Huysmans, Blatter, & van der Beek, 2012; Jens Wahlström, 2005; J. Wahlström, Hagberg, Toomingas, & Wigaeus Tornqvist, 2004). Les douleurs et les inconforts dus aux différentes tendinopathies, à l'arthrose ou aux autres types de troubles musculo-squelettiques seraient directement liés à des pertes de production de l'ordre de 10 à 20 % (Kermit G. Davis & Kotowski, 2015). Face à l'ampleur de la problématique recensée dans les pays occidentaux, l'OMS a identifié les milieux de travail comme le principal lieu pour l'implantation de programmes pour la promotion de l'activité physique afin de combattre la sédentarité.

La sédentarité en milieu de travail

L'augmentation des comportements sédentaires serait principalement liée au changement sociétal. Depuis l'étude de Morris et al. (1953) qui ont observé pour une première fois l'augmentation des risques de mortalité chez les travailleurs sédentaires dans les années 1950 (Blair et al., 2010), on a observé une augmentation du plus de 40 % du temps sédentaire dont plus de 49 % seraient attribuables au travail (Parry & Straker, 2013). Aux États-Unis cette tendance s'accentue. Entre les années 1960 et 2010, les emplois demandant une activité physique d'intensité légère à moyenne sont passés de 50 % à moins de 20 % favorisant les comportements sédentaires au travail (Church et al., 2011). Pour les travailleurs, cette transition du temps actif à sédentaire représente une diminution de la dépense calorique quotidienne de 110 à 150 kcal/jour (Church et al., 2011).

Plusieurs études confirment qu'actuellement le temps assis représente entre 50 et 80 % du temps total au travail par jour (Evans et al., 2012; Genevieve N. Healy et al., 2013; Ryan, Dall, Granat, & Grant, 2011; Waters et al., 2016). On remarque que les proportions d'heures assises sont généralement plus élevées les jours travaillés pour les personnes occupant un emploi sédentaire (Salmon, Owen, Crawford, Bauman, & Sallis, 2003). Aux États-Unis, on estime pour 2018 que 26 % des travailleurs pratiquent un emploi sédentaire, soient 30 millions de travailleurs (U.S. Bureau of Labor Statistics, 2018), et qu'ils cumulent jusqu'à 66 % de leur temps en position assise, soit sédentaire (Ryde, Brown, Gilson, & Brown, 2014). Au Canada, plus de 8,7 millions de travailleurs exercent un métier dit sédentaire, travaillant en moyenne 7,9 heures par jour (Public health agency of Canada; Statistics Canada, 2017). On estime que ceux-ci passent plus de 77 à 80 % de leur temps au travail en période assise et de manière prolongée (Public health agency of Canada). De manière plus alarmante, on estime que la Chine et le Brésil atteindront des taux de sédentarité au travail similaires à l'Amérique du Nord en 2020, ce qui représente des centaines de millions de travailleurs (Ng & Popkin, 2012).

À ce stade, la question à se poser est : comment pouvons-nous diminuer le temps sédentaire au travail et intégrer plus d'activité physique dans nos milieux de travail (N. Owen, Bauman, & Brown, 2009) ? Plusieurs pays occidentaux ont élaboré des programmes de promotion de la santé qui s'attaquent directement à la sédentarité dans les milieux de travail (Centers for Disease Contril and Prevention, 2017; National Institute for Health and Care Excellence, 2008; Public health agency of Canada). Parmi les actions proposées aux travailleurs et aux employeurs, on retrouve des activités tels que les transports actifs, l'utilisation des escaliers, les réunions actives (ex. debout ou à la marche) et les activités sportives sur les heures du diner. Toutefois, les approches utilisées jusqu'à présent dans les milieux de travail (ex. rappel via courriel de changer de posture, activité de marche au travail et intervention basée sur des activités physiques au travail) n'ont pas permis de diminuer le temps sédentaire de manière significative (Keadle, Conroy, Buman, Dunstan, & Matthews, 2017; Prince, Saunders, Gresty, & Reid, 2014; Nipun Shrestha et al., 2016). De plus, il n'est pas clair si l'activité physique pratiquée sur les milieux de travail permet d'avoir de réels bénéfices sur la santé cardiométabolique et sur la fatigue mentale (Hallman, Mathiassen, Gupta, Korshøj, & Holtermann, 2015; Holtermann, Krause, van der Beek, & Straker, 2018; Holtermann, Mathiassen, & Straker, 2019.

Bureaux actifs - Postes de travail actifs versus postes assis

Depuis les trois dernières décennies, la recherche scientifique s'intéresse à de nouveaux designs de poste de travail. Parmi la panoplie d'appareils que l'industrie de l'ergonomie propose, plusieurs études se sont intéressées aux postes de travail qui permettent de varier les postures : passer d'une posture assise à debout ; marcher sur tapis roulant à même le poste de travail et pédaler avec pédaliers sous la table de travail. Le plus souvent nommés « bureaux actifs », ces différents postes de travail permettent aux travailleurs d'augmenter l'activité musculaire journalière et de fragmenter le temps prolongé en posture assise tout en conservant une certaine efficience aux tâches de travail. Dans la littérature scientifique, ces postes de travail sont séparés en deux catégories : 1) les postes actifs statiques (debout) qui permettent une alternance de position de travail entre debout et assis. Ces postes sollicitent les muscles des membres inférieurs et la mobilité au niveau lombaire et cervical; 2) les postes actifs dynamiques (avec tapis roulant ou avec pédalier) qui augmentent l'activité musculaire des membres inférieurs et stabilisateurs du tronc et augmentent la dépense énergétique pendant le travail.

Les intensités d'exercice jugées adéquates pour les tâches de travail avec l'usage des postes dynamiques sont de 1,6 km/h à 3,2 km/h pour le bureau à tapis roulant et de 5 watts à 30 watts pour le bureau à pédalier (L. Straker, Levine, & Campbell, 2009; Thompson & Levine, 2011).

Temps assis

Une multitude d'études rapporte que l'ajout d'un poste actif au poste conventionnel assis diminue le temps sédentaire au travail. Cette réduction serait, selon les différents articles de revue et méta-analyses, entre 30 et 120 minutes par jour pour les postes debout (Hutcheson, Piazza, & Knowlden, 2018; Nipun Shrestha et al., 2016), de 23 à 60 minutes par jour pour les postes avec pédalier (Neuhaus et al., 2014b; Nipun Shrestha et al., 2016) et de 2 à 55 minutes pour les postes avec tapis roulant (Hutcheson et al., 2018; Nipun Shrestha et al., 2016). Tel que détaillé par la suite, l'apport de temps actif des postes de travail actifs comparativement aux postes de travail assis suppose des effets sur des biomarqueurs physiologiques, biomécaniques et de productivité au travail incluant le bien-être au travail. L'ensemble de ces observations aurait potentiellement un impact sur l'amélioration globale de la santé des travailleurs (Tine Torbeyns, Bailey, Bos, & Meeusen, 2014).

L'utilisation des bureaux actifs et de leurs effets physiologiques

L'apport d'activité physique à basse intensité et la diminution du temps prolongé assis par l'utilisation de postes actifs pourraient avoir des bienfaits intéressants sur la santé métabolique. Une étude de revue de littérature rapporte des augmentations de la dépense énergétique allant jusqu'à 37 % avec l'usage du poste debout comparativement aux postes assis conventionnels (Tudor-Locke, Schuna, Frensham, & Proenca, 2014). Toujours en comparaison avec le poste conventionnel, des augmentations de la dépense énergétique de plus de 150 % sont rapportées avec l'usage d'un pédalier ou d'un tapis roulant pour des intensités maximales de 40 watts pour le pédalier et 3,2 km/h pour le tapis roulant (Betts et al., 2019; Botter et al., 2016; Cox et al., 2011; Elmer & Martin, 2014; MacEwen, MacDonald, & Burr, 2015; Reiff, Marlatt, & Dengel, 2012; Tudor-Locke et al., 2014). Malgré ces faibles intensités (1,5 METS poste debout; 2,8 METS poste avec pédalier et avec tapis roulant), la dépense énergétique engendrée par l'utilisation de ces appareils peut contribuer à la régulation pondérale, plus particulièrement pour les populations avec obésité (Josaphat et al., 2019).

En lien avec l'augmentation de la dépense calorique, certains résultats démontrent une augmentation de la fréquence cardiaque avec l'usage des bureaux actifs (Botter et al., 2016; Cox et al., 2011; Tudor-Locke et al., 2014). Toutefois, il n'est pas clair si l'usage du poste debout augmente la fréquence cardiaque comparativement au poste assis conventionnel (Altenburg, Rotteveel, Serné, & Chinapaw, 2019). Il est proposé que la sollicitation cardio-vasculaire serait simplement trop basse. Cependant, dans les protocoles d'étude qui demandaient aux participants d'ajouter des tâches telles que parler au téléphone ou dactylographier en étant debout, les résultats montrent une légère augmentation de la fréquence cardiaque (Betts et al., 2019; Botter et al., 2016; Cox et al., 2011; Leon Straker & Mathiassen, 2009). Concernant les postes dynamiques (tapis roulant et pédalier), lorsque comparés avec le poste assis, différents auteurs rapportent des augmentations similaires allant entre 14 et 26 battements par minute. Ces augmentations ont été mesurées pour des intensités de 0,6 à 3,2 km/h pour le poste avec tapis et de 9 à 30 watts pour le poste à pédalier (Botter et al., 2016; Cox et al., 2011; L. Straker et al., 2009).

L'usage des postes actifs a un effet positif sur la pression artérielle comparativement au poste assis pour les personnes en embonpoint (indice de masse corporel (IMC) ≥25 $kg{\cdot}m^{-2}$) et obèse (IMC >30 $kg{\cdot}m^{-2}$). En effet, avec l'usage du poste debout, une baisse de 5 mmHg de la pression systolique est observée pendant les tâches de la journée et peut perdurer jusqu'à deux heures après celle-ci lorsque comparé au poste assis (Zeigler, Mullane, Crespo, Buman, & Gaesser, 2016). Pour cette même population, ces effets sont aussi observés pour les postes à pédalier (baisse de 7 mmHg) et pour le poste à tapis roulant (baisse de 4 mmHg). Chez les personnes avec un IMC normal, aucune différence de la pression systolique n'est observée avec l'usage du poste debout (Altenburg et al., 2019; Cox et al., 2011). Toujours chez les personnes avec un IMC normal, l'utilisation de manière intermittente du poste à pédalier permettrait une diminution de la pression systolique (baisse de 3 mmHg) (Carr, Karvinen, Peavler, Smith, & Cangelosi, 2013). De manière similaire, l'utilisation du poste à tapis roulant de manière intermittente (20 minutes à toute les heures) permettrait une baisse de 3 mmHg (Champion et al., 2018).

Chacun des trois bureaux actifs aurait des effets bénéfiques sur l'hypercholestérolémie (Champion et al., 2018; Crespo, Mullane, Zeigler, Buman, & Gaesser, 2016) et sur la régulation glycémique postprandiale (Champion et al., 2018; Crespo et al., 2016; MacEwen et al., 2015; Pulsford, Blackwell, Hillsdon, & Kos, 2017; N. Shrestha et al., 2018). Toutefois, concernant ces deux derniers marqueurs physiologiques, plus d'études devront être faites afin de mettre en évidence l'impact des trois différents postes actifs comparativement au poste assis. Il est suggéré que plus d'études randomisées avec des tailles d’échantillons plus grandes soient réalisées afin d’obtenir un plus haut niveau d’évidences scientifiques (N. Shrestha et al., 2018).

L’utilisation des bureaux actifs et leurs effets sur la biomécanique et les troubles musculo-squelettiques

Parmi les problématiques de santé au travail, les troubles musculo-squelettiques sont un enjeu couteux (Kalkis, 2015). Plusieurs études suggèrent que l’utilisation du poste debout permet une diminution de la douleur et de l’inconfort dans le bas et haut du dos et au niveau du cou comparativement à l’usage exclusif du poste assis (K. G. Davis & Kotowski, 2014; Fedorowich, Emery, & Cote, 2015; Husemann, Von Mach, Borsotto, Zepf, & Scharnbacher, 2009; Karakolis & Callaghan, 2014; Pronk, Katz, Lowry, & Payfer, 2012). Concernant le poste à pédalier, les effets de l’activité musculaire seraient négligeables et n’affecteraient pas ou peu les tâches motrices qu’exigent le travail de bureau (Baker, Coenen, Howie, Williamson, & Straker, 2019; Elmer & Martin, 2014; Yoon, Lefrançois-Daignault, & Côté, 2019) . Tandis que pour le poste avec tapis roulant, une activité musculaire plus élevée au niveau des muscles du trapèze ainsi qu’une modification du schème musculaire au niveau des muscles spinaux est rapportée (Botter et al., 2016; Chau et al., 2016). Ces modifications apporteraient pour les travailleurs une réduction de l’inconfort dans des tâches de bureau par rapport à l’utilisation exclusive du poste assis (Fedorowich et al., 2015). Finalement, quelques auteurs soulèvent des doutes sur la sécurité, notamment sur les chutes avec l’utilisation du poste à la marche, et de la fatigue musculaire engendrée par le poste à pédalier (Botter et al., 2016; Elmer & Martin, 2014; MacEwen et al., 2015).

Les bureaux actifs et la productivité au travail

L’évaluation de la productivité au travail est rapportée dans la grande majorité des études selon trois axes : la performance dans les tâches à l’ordinateur, les performances cognitives et le mieux-être des travailleurs dans la tâche.

L’impact des bureaux actifs sur les tâches à l’ordinateur

L’apport des postes actifs par rapport au poste assis conventionnel pour les performances dactylographiques et de pointage à l’ordinateur ne semble pas à priori présenter de grandes améliorations sur la productivité, au contraire. Le poste debout serait le seul pour qui les résultats ne démontrent aucune diminution des performances de vitesse de frappe, de pointage avec souris ou de score d’exactitude (Drury et al., 2008; Husemann et al., 2009; L. Straker et al., 2009). Toutefois, après 90 minutes d’utilisation consécutive du poste debout, on dénote une diminution des performances dactylographiques due à la fatigue ou l’inconfort (Fedorowich et al., 2015; Hasegawa, Inoue, Tsutsue, & Kumashiro, 2001). En ce qui a trait au poste à pédalier, des diminutions de performances sur les tâches de pointage avec souris sont rapportées comparativement aux postes assis (Commissaris et al., 2014; Elmer & Martin, 2014; Leon Straker & Mathiassen, 2009; Tine Torbeyns et al., 2016; Yoon et al., 2019). Par exemple, on observe une légère diminution des performances à l’utilisation de la souris avec des intensités de 5 à 30 watts (perte de vitesse de frappe de 5 % et perte de l’exactitude du pointage de 65 %) comparativement à la posture assise (L. Straker et al., 2009). Avec des intensités allant au-delà de 40 watts, on note une perte de vitesse de frappe de ±deux mots par minutes et une augmentation de ±vingt erreurs de frappe par minutes (Tronarp et al., 2018). Concernant l’utilisation du poste avec tapis roulant, les études sont unanimes à savoir que les performances dactylographiques et de pointage diminuent comparativement au poste assis (Commissaris et al., 2014; Funk et al., 2012; Larson et al., 2015; MacEwen et al., 2015; Mullane, Buman, Zeigler, Crespo, & Gaesser, 2017; Ojo, Bailey, Chater, & Hewson, 2018; L. Straker et al., 2009). Selon Straker et al. (2009), les performances de vitesse à la dactylographie diminueraient d’environ 6 % pour la vitesse de frappe et de 3 % pour le nombre d’erreurs. Les performances de vitesse de pointage avec la souris diminueraient de 14 % avec une diminution de 106 % d’erreur sur la cible à atteindre. Plus l’intensité la vitesse de marche augmente, plus les performances diminuent. Quelques auteurs expliquent que le mouvement de la marche provoque une oscillation qui doit être stabilisée par les muscles du tronc et de la ceinture scapulaire (Botter et al., 2016; Fedorowich et al., 2015). Après une durée de 90 minutes d’utilisation, cette activité musculaire du haut du corps provoquerait une diminution de la motricité fine que demandent les tâches faites à l’ordinateur telles que l’écriture et le pointage (Botter et al., 2016; Commissaris et al., 2014; Fedorowich et al., 2015).

Effets des bureaux actifs sur la cognition

Les effets des bureaux actifs sur les capacités cognitives (attention, mémoire, résolution de problème et temps de réaction) n'ont pas été étudiés autant que les facteurs présentés dans les sections précédentes. Néanmoins, les résultats rapportés à ce jour indiquent que l'usage d'un poste de travail debout aurait peu d'influence sur les paramètres d'attention, de mémoire, de capacité de raisonnement et de temps de réaction (Bantoft et al., 2016; Commissaris et al., 2014; Drury et al., 2008). Ce type de poste serait donc comparable au poste conventionnel assis. Concernant le poste à pédalier, des améliorations de vitesse de l'ordre de 30 à 100 millisecondes sont rapportées pour des tâches d'identification d'un stimulus visuel (Stroop color test) (Huang et al., 2019; Ohlinger, Horn, Berg, & Cox, 2011; Tine Torbeyns et al., 2016). Cependant, le poste avec pédalier comparé au poste assis n'apporterait aucun avantage sur l'attention et lors de tâches de raisonnement (Huang et al., 2019). Concernant le poste avec tapis roulant, une étude dénote une amélioration de 34,9 % de bonnes réponses suite à une tâche de mémorisation à court terme (10 minutes après la tâche de mémorisation). Toutefois, malgré les résultats cités ci-dessus, une étude de revue de la littérature ne rapporte aucune différence significative et peu de taille d'effet (Ojo et al., 2018). Une autre étude observe au contraire une détérioration des tâches cognitives, telle que la mémorisation (Zhang, Zhang, Cao, & Chen, 2018). Les résultats traitant des effets des bureaux actifs sur la cognition devront être plus étoffés pour conclure.

Utilisation des bureaux actifs et bien-être au travail

Les marqueurs de bien-être les plus souvent évalués dans les études sur bureaux actifs sont l'état d'éveil, l'ennui, le stress et la satisfaction de son environnement de travail. Concernant le poste de travail debout, une étude rapporte pour leurs participants (n=24) des effets positifs avec 75 % des participants qui se sentaient plus éveillés, 66 % plus focalisés lors des tâches, 63 % plus heureux au travail et 63 % plus productifs (Pronk et al., 2012). Plus récemment, des résultats sur l'éveil au travail et le sentiment d'être plus productif à l'aide du poste de travail debout ont également été rapportés (Renaud, Huysmans, van der Ploeg, Speklé, & van der Beek, 2018). De plus, le poste debout comparativement au poste traditionnel assis pourrait améliorer l'humeur, diminuer la fatigue et diminuer le désir de manger pendant la journée de travail (Dutta, Koepp, Stovitz, Levine, & Pereira, 2014).

L'usage du poste avec pédalier comparativement au poste assis améliore la bonne humeur au travail et la motivation (Pilcher & Baker, 2016; Tine Torbeyns et al., 2016). De plus, suite à leur utilisation, des tailles d'effet élevées ont été rapportées entre l'usage du poste à pédalier et le poste assis sur l'état d'éveil (d=0,94), la diminution de l'ennui au travail (d=1,15), la satisfaction au travail (d=0,84) et des tailles d'effets moyennes ont été rapportées pour la diminution du stress (d= 0,49) (Sliter & Yuan, 2015). Concernant le poste avec tapis roulant, les valeurs de taille d'effet étaient élevées pour l'état d'éveil (d=0,77), la diminution de l'ennui au travail (d=1,13), la satisfaction au travail (d=1,03) et moyennes pour la diminution du stress (d=0,51) (Sliter & Yuan, 2015). Finalement, l'utilisation du poste debout et du poste à tapis roulant ralentirait l'augmentation du cortisol salivaire (marqueur physiologique du stress) au cours de la journée de travail (Δ-1.5nmol/l pour le poste avec tapis et Δ-1.6nmol/l. avec le poste debout) (Gilson, Hall, Renton, Ng, & Hippel, 2017).

En conclusion, les bureaux actifs sont certainement une partie de la solution à la problématique de la sédentarité au travail (Carnethon et al., 2009). En portant attention aux différents résultats recensés précédemment, il semble y avoir une différence d'effets sur les marqueurs physiologiques, biomécaniques et de productivité au travail incluant le bien-être au travail selon le type de poste actif utilisé par les participants. À ce jour, aucun article de revue de la littérature n'a recensé ces différences entre les postes de travail actifs. Le premier article présenté dans ce mémoire fait une recension des écrits et compare les effets physiologiques, biomécaniques et de productivité au travail entre les trois postes de travail actifs (debout, tapis roulant et pédalier).

Article #1

Health and Productivity at work: Which active workstation for which benefits– A Systematic Review

Statut: Publié

Auteurs :

Dupont, F., Léger, P.-M., Begon, M., Lecot, F., Sénécal, S., Labonté-Lemoyne, E., & Mathieu, M.-E. (2019). Health and productivity at work: which active workstation for which benefits: a systematic review. Occup Environ Med, 76(5), 281. doi:10.1136/oemed-2018-105397

Lien URL : https://oem.bmj.com/content/76/5/281

Health and Productivity at work: Which active workstation for which benefits– A Systematic Review

François Dupont[1], Pierre-Majorique Léger[2], Mickael Begon[1,3], François Lecot[1], Sylvain Sénécal[2], Elise Labonté-Lemoyne[2], Marie-Eve Mathieu[1,3]

Affiliations:

1: École de kinésiologie et des sciences de l’activité physique, Université de Montréal, Montréal, Canada.

2: Tech3Lab, HEC Montréal, Montréal, Canada.

3: Research center, Sainte-Justine University Hospital Center, Montréal, Canada.

Corresponding author:

Prof. Marie-Eve Mathieu,

Université de Montréal, École de kinésiologie et des sciences de l’activité physique,2100, boul. Edouard-Montpetit, Bureau 8202, Montreal, QC, CAN H3T1J4, 514-343-6737; me.mathieu@umontreal.ca

Contributorship:

FD wrote the initial draft; FD and FL screened and evaluated the articles; all the authors revised the article; MEM initiated and supervised all stages of the project.

Funding: Grant FIT24-health and productive work # 146019 initiative by Social Sciences and Humanities Research and Canadian Institutes of Health Research.

Competing interests: The authors declare no conflict of interest.

Abstract

Objectives In order to reduce sedentary behaviour at work, research has examined the effectiveness of active workstations. However, despite their relevance in replacing conventional desks, the comparison between types of active workstations and their respective benefits remains unclear. The purpose of this review article is thus to compare the benefits between standing, treadmill and cycling workstations.

Methods Search criteria explored Embase, PubMed and Web of Science databases. The review included studies concerning adults using at least two types of active workstations, evaluating biomechanical, physiological, work performance and/or psychobiological outcomes.

Results Twelve original articles were included. Treadmill workstations induced greater movement/activity and greater muscular activity in the upper limbs compared to standing workstations. Treadmill and cycling workstations resulted in elevated heart rate, decreased ambulatory blood pressure and increased energy expenditure during the workday compared to standing workstations. Treadmill workstations reduced fine motor skill function (i.e. typing, mouse pointing and combined keyboard/mouse tasks) compared to cycling and standing workstations. Cycling workstations resulted in improved simple processing task speeds compared to standing and treadmill workstations. Treadmill and cycling workstations increased arousal and decrease boredom compared to standing workstations.

Conclusions The benefits associated with each type of active workstation (e.g. standing, treadmill, cycling) may not be equivalent. Overall, cycling and treadmill workstations appear to provide greater short-term physiologic changes than standing workstations that could potentially lead to better health. Cycling, treadmill and standing workstations appear to show short-term productivity benefits; however, treadmill workstations can reduce the performance of computer tasks.

Key messages

What is already know about this subject?

- Physical demands in the work environment have declined in Western countries over the last decades resulting in new types of negative health concerns.
- Active workstations such as standing, walking and cycling may reduce sitting time and could enhance health and productivity at work.

What are the new findings?

- The benefits associated with each type of active workstation (e.g. standing, treadmill, cycling) may not be equivalent.
- Cycling and treadmill workstations appear to provide greater short-term physiologic changes than standing workstations that could potentially lead to better health.
- Cycling, treadmill and standing workstations appear to show short-term productivity benefits, while treadmill workstations reduce the performance of computer related work.

How might this impact research and corporate policy in the foreseeable future?

These results are relevant in order to optimize future workplace interventions. Workers and corporations should be able to look at the benefits and limits of each type of workstation and determine which one is most appropriate for workers' specific needs and tasks.

Introduction

In 2013, costs associated with sedentary behaviour were estimated at $65.5 billion worldwide.[1] Moreover, a shift from manual labour jobs to highly sedentary service industry and office-based professions has been observed over the last decades.[2] Recently, researchers have begun to study interventions designed to break up and reduce sedentary time throughout the workday by replacing the sitting workstation, which promotes sedentary behaviour,[3] with active workstations.

Standing, treadmill or cycling workstations change the ergonomic paradigm of the 09h00 to 17h00 workday, allowing a change in posture (i.e. sitting vs. standing) and improved muscle activation (i.e. none vs. muscular contractions) during work activities (Fig. 1). Many studies suggest that active workstations could reduce sedentary time at work,[4-6] maintain work productivity,[6] increase energy expenditure,[7] regulate high blood pressure,[8] relieve back pain,[9] enhance positive affect,[10] and increase cognitive abilities[11] compared to conventional seated workstations.

Considering the growing body of evidence that suggests that standing, treadmill and cycling workstations may improve health and productivity at work compared to seated workstations, it would be relevant to have a better understanding of what benefits are specific to each of these active workstations. The purpose of this review article is thus to compare the benefits between standing, treadmill and cycling workstations.

Methods

Eligibility and Exclusion Criteria

To be included in this review, studies were required to be published in peer-reviewed academic journals, written in English and respect PICOS criteria (Table 1). Participant criteria included adult population, healthy or with cardiometabolic disorders and free of musculoskeletal complaints. Studies were required to include at least two types of active workstations. Both laboratory and free-living environment intervention protocols were included. Studies also needed to evaluate biomechanical, physiological, psychobiological, and/or cognitive outcomes. Studies were excluded if active workstations were not standing, treadmill or cycling based, and included “interest of use” or “social acceptance” outcomes.

Literature Search and Study Selection

A computer-assisted systematic search of Central, Embase, PubMed and Web of Science databases was conducted on 13/03/2018 and included all studies prior to that date. The following key words were used: “desks”, “workstation”, *work station, *works station and the following Boolean phrase: active OR bik* OR cycling OR “height adjustable” OR stepping OR “stand up” OR standing OR treadmill* OR walk* OR elliptical OR bicycl* OR pedaling OR “stability ball” OR “stability balls” OR “exercise ball” OR “exercise balls” OR “swiss ball” OR “swiss balls” OR “sit-to-stand” OR “sit stand.

A first study selection was completed independently by two reviewers (FD, FL) based on the “inclusion of at least two active workstations” by screening titles and abstracts. A final selection was made according to eligibility criteria by one reviewer (FD) using full texts.

Data Extraction and Results Presentation

Data extraction process was completed by FD. Relevant outcomes were collected, analyzed and summarized. Only significant differences (i.e. mean values, z-scores, percentile, etc.) were reported in the review. Effect size (Cohen’s *d*) has been calculated for all significant differences.

Quality Assessment

Two authors (FD, FL) used the Modified Downs and Black checklist[12] based on 27 “yes”-or-’no’ items across five sections of quality assessments to determine risk of bias: 1. Study quality; 2. External validity; 3. Study bias; 4. Confounding and selection bias; and 5. Power of the study.

Data Item

Table 1. PICOS (Participants, interventions, comparators, outcomes, study designs)

PICOS	DETAILS
Participants	At least 18 years old. Adults presenting cardiometabolic disorders and healthy adults.
Interventions	Intervention with conventional seats, seated active workstations (e.g. cycling desk and elliptical pedal desk), and upright active workstations (e.g. standing desk, treadmill desk). Interventions were performed in a laboratory or free-living environment.
Comparative factors	Different types of workstations (i.e. standing, treadmill, recumbent pedal, elliptical pedal and cycling).
Outcomes	Biomechanical: measurement of muscle activation, posture and joint angles, as well as kinematics. Physiological: heart rate, oxygen consumption, energy expenditure, blood pressure, perceived exertion and pressure pain thresholds. Work performance: quantitative and qualitative measurements of typing, mouse pointing, multitasking, perception of task, attention to task, speech assessment, and memory tasks. Psychobiological: quantitative and qualitative measurement of arousal, stress, boredom, task satisfaction, and quantitative measurement of salivary cortisol and encephalography.
Study designs	Pilot study, randomized crossover full-factorial study, randomized repeated measures design, within participant experimental design, experimental mixed-model study.

Results

Out of the 1,352 studies identified through computer search, 274 examined the effects of active workstations (Fig. 2). Twelve studies met eligibility criteria (Table 2) and their quality was assessed (Table 3). Studies were diverse in terms of outcomes, measures, and study design. Selected studies used different taxonomies to define “active workstation”, and we regrouped them as follows: 1) standing workstations, 2) walking workstations (speed expressed in km/h), and 3) pedalling/elliptical workstations [power expressed in Watts (W) and in maximum aerobic power (MAP)]. Conventional seated workstations were present in selected studies, but are beyond the scope of the present review.

Table 2

Overview of studies

Authors / Study	Design	Intervention duration	Sample (N)	Population Characteristics	Experimental conditions	Measures	Results	Effect size (Cohen's d)
Bantoft, et al. [21]	Counterbalanced randomized control trial	60min/task/day 7 tasks on 7 days	Males = 13 Females = 32	22.7 years old Healthy undergraduate students	Sitting Sitting/standing Treadmill (1-3 km/h)	Intellectual capacity Anxiety and depression Verbal short-term memory Verbal working memory Visuomotor speed and learning Verbal working memory and attention	All results were non-significant.	N/A
Botter, et al. [13]	Randomised repeated measures	+/- 4 hours	Males = 6 Females = 6 EMG subgroup: Males = 5 Females = 5	38.7 years old	Sitting Standing Treadmill (0.6 km/h) Treadmill (2.5 km/h) Elliptical (9W) Elliptical (17W)	Muscle activation by EMG (% of maximal voluntary muscular contraction of trapezius and erector spinae) Posture and joint angles (head inclination, cervical spine flexion, L5 inclination, trunk frontal inclination, trunk lateral inclination, back flexion) Motion analysis (total body, head, thoracic spine, lumbar spine L1, lumbar spine L5 arms, legs)	Comparisons were only done between standing and treadmill experimental conditions (upright posture). Trapezius right (%MVC) mean values of the 50th percentile: standing (3.8 %MVC) vs. treadmill$_{2.5\ km/h}$ (8.1 %MVC). Trapezius right (%MVC) mean values of the 95th percentile: standing (9.3 %MVC) vs. treadmill$_{2.5\ km/h}$ (17.2 %MVC). Trapezius left (%MVC) mean values of the 50th percentile: standing (5.8 %MVC) vs. treadmill$_{2.5\ km/h}$ (8.1 %MVC). Trapezius left (%MVC) mean values of the 95th percentile: standing (10 %MVC) vs. treadmill$_{2.5\ km/h}$ (22.9 %MVC). Treadmill$_{2.5\ km/h}$ increase muscle activation of the upper limb compared to standing. Motion analysis:	Trapezius (%MVC) right50th treadmill$_{2.5\ km/h}$vs. standing= 0.87 Trapezius (%MVC) right 95th treadmill$_{2.5\ km/h}$vs. standing= 0.83 Trapezius left (%MVC) 50th treadmill$_{2.5\ km/h}$vs. standing= 0.43 Trapezius left (%MVC) 95th treadmill$_{2.5\ km/h}$ vs. standing= 0.97 Total body(%g) 50th percentile treadmill$_{2.5\ km/h}$vs. standing = 7.08 Total body(%g) 95th percentile treadmill$_{2.5\ km/h}$vs. standing = 6.63 Total body(%g) 50th percentile treadmill$_{0.6\ km/h}$vs. standing = 3.07 Total body(%g) 95th percentile treadmill$_{0.6\ km/h}$vs. standing = 2.04 Head (%g) 50th percentile treadmill$_{2.5\ km/h}$vs. standing = 5.47

Heart rate Energy expenditure	Total body(%g) mean values of the 50th percentile: standing (0.8 %g) vs. treadmill$_{0.6\ km/h}$ (3.7 %g) and treadmill$_{2.5\ km/h}$ (14.9 %g). Total body (%g) Mean values of the 95th percentile: standing 2 %g vs. treadmill$_{0.6\ km/h}$ (5.3 %g) and treadmill$_{2.5\ km/h}$ (17.1 %g). Head (%g) mean values of the 50th percentile: standing 0.7 %g vs. treadmill$_{0.6\ km/h}$ (2.9 %g) and treadmill$_{2.5\ km/h}$ (8.9 %g). Thoracic spine (%g) mean values of the 50th percentile: standing (0.8 %g) vs. treadmill$_{0.6\ km/h}$ (2.3 %g) and treadmill$_{2.5\ km/h}$ (9.6 %g). Thoracic spine (%g) mean values of the 95th percentile: standing (1.5 %g) vs. treadmill$_{0.6\ km/h}$ (3.5 %g) and treadmill$_{2.5\ km/h}$ (11.5 %g). Lumbar spine L1 (%g) mean values of the 50th percentile: standing (0.8 %g) vs. treadmill$_{0.6\ km/h}$ (2.5 %g) and treadmill$_{2.5\ km/h}$ (10.1 %g). Lumbar spine L1 (%g) Mean values of the 95th percentile: standing (1.5 %g) vs. treadmill$_{0.6\ km/h}$ (3.9 %g) and treadmill$_{2.5\ km/h}$ (12.2 %g). Lumber spine L5 (%g) mean values of the 50th percentile: standing (0.8 %g) vs. treadmill$_{0.6\ km/h}$ (2.8 %g) and treadmill$_{2.5\ km/h}$ (10.9 %g). Lumber spine L5 (%g) mean values of the 95th percentile: standing (1.6 %g) vs. treadmill$_{0.6\ km/h}$ (4.3 %g) and treadmill$_{2.5\ km/h}$ (13.3 %g). Arms (%g) mean values of the 50th percentile: standing (0.7 %g) vs. treadmill$_{0.6\ km/h}$ (2.9 %g) and treadmill$_{2.5\ km/h}$ (9.1 %g). Arms (%g) mean values of the 95th percentile: standing (2.8 %g) vs. treadmill$_{0.6\ km/h}$ 4.8 (%g) and treadmill$_{2.5\ km/h}$ 11.2 (%g).	Head (%g) 95th percentile treadmill$_{2.5\ km/h}$ vs. standing = 4.05 Head(%g) 50th percentile treadmill$_{0.6\ km/h}$ vs. standing = 1.88 Thoracic spine (%g) 50th percentile treadmill$_{2.5\ km/h}$ vs. standing = 5.91 Thoracic spine (%g) 95th percentile treadmill$_{2.5\ km/h}$ vs. standing = 6.29 Thoracic spine (%g) 50th percentile treadmill$_{0.6\ km/h}$ vs. standing = 2.63 Thoracic spine (%g) 95th percentile treadmill$_{0.6\ km/h}$ vs. standing = 1.96 Lumbar spine L1 (%g) 50th percentile treadmill$_{2.5\ km/h}$ vs. standing = 5.97 Lumbar spine L1 (%g) 95th percentile treadmill$_{2.5\ km/h}$ vs. standing = 6.46 Lumbar spine L1 (%g) 50th percentile treadmill$_{0.6\ km/h}$ vs. standing = 2.98 Lumbar spine L1 (%g) 95th percentile treadmill$_{0.6\ km/h}$ vs. standing = 2.35 Lumber spine L5 (%g) 50th percentile treadmill$_{2.5\ km/h}$ vs. standing = 4.92 Lumber spine L5 (%g) 95th percentile treadmill$_{2.5\ km/h}$ vs. standing = 5.28 Lumber spine L5 (%g) 50th percentile treadmill$_{0.6\ km/h}$ vs. standing = 3.12 Lumber spine L5 (%g) 95th percentile treadmill$_{0.6\ km/h}$ vs. standing = 2.41 Arms (%g) 50th percentile treadmill$_{2.5\ km/h}$ vs. standing = 5.55

							Legs (%g) mean values of the 50th percentile: standing (0.8 %g) vs. treadmill$_{0.6\ km/h}$ (5.2 %g) and treadmill$_{2.5\ km/h}$ (22.5 %g). Legs (%g) mean values of the 95th percentile: standing (2.2 %g) vs. treadmill$_{0.6\ km/h}$ (7.5 %g) and treadmill$_{2.5\ km/h}$ (25.8 %g). Treadmill$_{0.6km/h}$ and treadmill$_{2.5\ km/h}$ increase (%g) compared to standing workstation except for the head (%g) mean values of the 95th percentile. Heart rate mean values: standing (79.8), elliptical$_{9W}$ (86.8), elliptical$_{17W}$ (96.6), treadmill$_{0.6\ km/h}$ (81.4), treadmill$_{2.5\ km/h}$ (91.4). Elliptical$_{17W}$ and treadmill$_{2.5\ km/h}$ increase heart rate compared to standing. Energy expenditure (MET) values: standing (1.6), elliptical$_{9W}$ (2.4), elliptical$_{17W}$ (3.1), treadmill$_{0.6\ km/h}$ (1.8), treadmill$_{2.5\ km/h}$ (2.8). Treadmill$_{2.5\ km/h}$ increase energy expenditure compared to standing. All other results were non-significant.	Arms (%g) 95th percentile treadmill$_{2.5\ km/h}$ vs. standing = 3.90 Arms (%g) 50th percentile treadmill$_{0.6\ km/h}$ vs. standing = 3.15 Arms (%g) 95th percentile treadmill$_{0.6\ km/h}$ vs. standing = 1.06 Legs (%g) 50th percentile treadmill$_{2.5\ km/h}$ vs. standing = 6.79 Legs (%g) 95th percentile treadmill$_{2.5\ km/h}$ vs. standing = 6.41 Legs (%g) 50th percentile treadmill$_{0.6\ km/h}$ vs. standing = 2.78 Legs (%g) 95th percentile treadmill$_{0.6\ km/h}$ vs. standing = 2.07 Heart rate elliptical$_{17W}$ vs standing = 1.65 Heart rate treadmill$_{2.5\ km/h}$ vs standing = 1.63 Energy expenditure missing data.
Commissaris, et al. [25]	Randomised repeated measures	1 workday	Males = 7 Females = 8	29.0 years old BMI= 22.3 kg/m^2	Sitting Standing Treadmill (2.5 km/h) Elliptical (17W) Cycling (56W) Cycling (85 W)	Typing task (Number of characters typed/min) Reading and correcting task (Number of characters read/min) Reaction time test: Mouse task Multi directional cognitive task Fast counting task Eriksen Flanker N-Back test Telephone task	No statistical analyses have been done between active workstations.	N/A

Cox, et al. [14]	Randomised repeated measures	60 minutes	Males = 9 Females = 22	37 years old	Sitting Standing Treadmill (1.6 km/h)	Aerobic capacity Heart rate Blood pressure Perceived effort Dyspnea perception Speech assessment	$\text{Treadmill}_{1.61\ \text{km/h}}$ (7.4 ± 0.33) increased VO_2 demands compared to standing (4.0 ± 0.18). $\text{Treadmill}_{1.61\ \text{km/h}}$ increased heart rate compared to standing. SBP values mean ± S.E: standing (124 ± 3) and $\text{treadmill}_{1.61\ \text{km/h}}$ (129 ± 3). $\text{Treadmill}_{1.61\ \text{km/h}}$ lowered blood pressure compared to standing. Rating perceived effort values: standing (0.7/10) and $\text{treadmill}_{1.61\ \text{km/h}}$ (1.3/10). $\text{Treadmill}_{1.61\ \text{km/h}}$ increased perceived effort compared to standing. Dyspnea perception scores showed that treadmill perception of breathing effort was higher compared to standing. All other results were non-significant.	VO_2 $\text{treadmill}_{1.61\ \text{km/h}}$ vs. standing = 0.80 Heart rate $\text{treadmill}_{1.61\ \text{km/h}}$ vs. standing = missing data. SBP $\text{treadmill}_{1.61\ \text{km/h}}$ vs. standing = 0.29 Rating perceived effort $\text{treadmill}_{1.61\ \text{km/h}}$ vs. standing = 0.53 Dyspnea $\text{treadmill}_{1.61\ \text{km/h}}$ vs. standing = missing data.
Gilson, et al. [28]	Pilot study	1.5-hour work periods/day/ experimental condition	N=20 EEG sub group = 13 Salivary cortisol subgroup =16	23-63 years old	Sitting Sit/standing Sit/ treadmill (self-determined speed range between 1.6-4 km/h)	EGG Salivary cortisol	All results were non-significant.	N/A

Kruse, et al. [17]	Pilot study	1) 4 hours of uninterrupted sitting 2) 4 hours of sitting interrupted with four 10-min bouts of standing 3) 4 hours of sitting interrupted with four 10-min bouts of light-intensity desk cycling	Males=10 Females=3	35-50 years old BMI = 29.7 kg/m^2 Sedentary, overweight, and obese adults	Standing Cycling	Flow-mediated dilation Heart rate Blood pressure Calf circumferences before and after conditions	All results were non-significant.	N/A
Ohlinger, et al. [20]	Within-participants experimental	75 minutes for all assessments	N = 50	43.2 years old	Sitting, Standing Treadmill (1.6 km/h)	Short term auditory verbal memory Selective attention Simple motor skill	Simple motor skills decreased from Treadmill$_{1.6\ km/h}$ compared to standing. All other results were non-significant.	Simple motor skill treadmill$_{1.6\ km/h}$ vs. standing = 0.15
Mullane, et al. [219]	Randomized cross-over	8 hours/ experimental condition with bouts of 10, 15, 20 and 30 minutes on active workstation	Males = 2 Females = 7	30.0 years old BMI = 28.7 kg/m^2 Pre-hypertensive (N = 7)	Siting Standing Treadmill (1.6 km/h) Cycling (20W at 25-20 RPM)	Detection test (speed expressed in z-score and mean log 10 transformed reaction times for correct responses) One back test Set-shifting test	Detection test processing speed z-score: standing (-0.43 ± 0.97), and treadmill$_{1.6\ km/h}$ (-0.44 ± 0.96), cycling$_{20W}$ (0.17 ± 97). Processing speed time z-score of standing and treadmill$_{1.6\ km/h}$ workstations showed lower performance speed than cycling$_{20w}$ workstation. Detection test reaction time values: standing (2.72 ± 0.13 log10ms), treadmill$_{1.6\ km/h}$ (2.71 ± 0.13 log10ms) and cycling$_{20W}$ (2.66 ± 0.14 log10ms). Reaction time was faster for cycling$_{20W}$ compared to standing. All other results were non-significant.	Detection test processing speed cycling$_{20w}$ vs. treadmill$_{1.6\ km/h}$ = 0.63 Detection test processing speed cycling$_{20w}$ vs. standing $_{=}$ 0.61 Reaction time cycling$_{20W}$ vs. standing = 0.44

Sliter and Yuan [10]	Pilot study	35 minutes	N = 180	21.2 years old BMI = 23.9 kg/m^2 Undergraduate students	Sitting Standing Treadmill Cycling	Stress Arousal Boredom Task satisfaction Performance (number correct task; number of errors in task)	Treadmill (2.85 ± 0.36) increase arousal compared to standing (2.55 ± 0.42). Cycling increased arousal compared to standing. Treadmill decreased boredom compared to standing. Cycling decreased boredom compared to standing. Treadmill decreased stress compared to standing. Treadmill provided more task satisfaction than standing. Performance level (number of items completed correctly) showed a decrease of performance between cycling and standing. All other results were non-significant.	Arousal treadmill vs. standing = 0.77 Arousal Cycling vs. standing = 0.95 Boredom treadmill vs. standing = -1.84 Boredom cycling vs. standing = -1.82 Stress treadmill vs. standing = -0.77 Task satisfaction treadmill vs. standing = 0.58 Performance level cycling vs. standing = -0.68
Straker, et al. [15]	Experimental mixed-model	+/- 1 workday	Males = 14 Females = 16	22-64 years old BMI (Female) = 25.1 kg/m^2 BMI (Male) = 24.7 kg/m^2	Sitting Standing Treadmill (1.6 km/h) Treadmill (3.2 km/h) Cycling (5W) Cycling (30 W)	Typing speed (words/min) Typing accuracy (% typing errors) Typing perceived speed Typing perceived accuracy Mouse pointing speed (millisecond) Mouse task accuracy (actual errors) Mouse perceived speed Mouse perceived accuracy Combined keyboard and mouse speed (words/sec) and error Combined keyboard and mouse task perceived speed and error	Typing speed task values: Standing (54.09), treadmill$_{1.6\ km/h}$ (50.14), treadmill$_{3.2\ km/h}$ (49.74), cycling$_{5W}$ (52.58), cycling$_{30W}$ (53.217). Typing speed was less for treadmill$_{1.6\ km/h}$, treadmill$_{3.2\ km/h}$, cycling$_{5W}$ and cycling$_{30W}$ compared to standing. Typing perceived speed scores: standing (2.86), treadmill$_{1.6\ km/h}$(3.56), treadmill$_{3.2\ km/h}$ (3.58), cycling$_{5W}$ (3.45), cycling$_{30W}$ (3.48). Result showed a decrease of typing speed perception for treadmill$_{1.6\ km/h}$, treadmill$_{3.2\ km/h}$, cycling$_{5W}$ and cycling$_{30W}$ compared to standing. Typing perceived accuracy scores: standing (2.99), treadmill$_{1.6\ km/h}$(3.79), treadmill$_{3.2\ km/h}$ (3.79), cycling$_{5W}$ (3.49), cycling$_{30W}$ (3.55). Scores showed a decrease of accuracy perception for treadmill$_{1.6\ km/h}$, treadmill$_{3.2\ km/h}$, cycling$_{5W}$ and cycling$_{30W}$ compared to standing. Also, scores showed a decrease of accuracy perception for treadmill$_{1.6\ km/h}$ compared to cycling$_{5W}$.	Typing speed treadmill$_{3.2\ km/h}$ vs. standing = -0.04 Typing speed treadmill$_{1.6\ km/h}$ vs. standing = -0.10 Typing speed cycling$_{5W}$ vs. standing = -0.04 Typing speed cycling$_{30W}$ vs. standing = -0.02 Typing perceived speed treadmill$_{3.2\ km/h}$ vs. standing = 0.56 Typing perceived speed treadmill$_{1.6\ km/h}$ vs. standing = 0.63 Typing perceived speed cycling$_{5W}$ vs. standing = 0.57 Typing perceived speed cycling$_{30W}$ vs. standing = 0.57

Heart rate Exertion	Mouse speed task values: standing (959.39), treadmill$_{1.6\ km/h}$ (1059.54), treadmill$_{3.2\ km/h}$ (1107), cycling$_{5W}$ (1022.28), cycling$_{30W}$ (1001.62). Results showed a decrease of performance for treadmill$_{1.6\ km/h}$, treadmill$_{3.2\ km/h}$ and cycling$_{5W}$ compared to standing. Also, results showed a decrease of speed between treadmill$_{1.6\ km/h}$ and treadmill$_{3.2\ km/h}$ compared to cycling$_{5W}$. Results showed a decrease of speed for treadmill$_{3.2\ km/h}$ compared to cycling$_{30W}$. Mouse task perceived speed scores: standing (2.55), treadmill$_{1.6\ km/h}$ (3.47), treadmill$_{3.2\ km/h}$ (3.54), cycling$_{5W}$ (3.19), cycling$_{30W}$ (3.26). Result showed a decrease of speed perception for treadmill$_{1.6\ km/h}$, treadmill$_{3.2\ km/h}$, cycling$_{5W}$ and cycling$_{30W}$ compared to standing. Result showed a decrease of speed perception for treadmill$_{1.6\ km/h}$, treadmill$_{3.2\ km/h}$, compared to cycling$_{5W}$ and cycling$_{30W}$.	Typing perceived accuracy treadmill$_{3.2\ km/h}$ vs. standing = 0.70 Typing perceived accuracy treadmill$_{1.6\ km/h}$ vs. standing = 0.68 Typing perceived accuracy cycling$_{5W}$ vs. standing = 0.63 Typing perceived accuracy cycling$_{30W}$ vs. standing = 0.66 Typing perceived accuracy treadmill$_{1.6\ km/h}$ vs. cycling$_{5W}$ = 0.1 Mouse speed treadmill$_{3.2\ km/h}$ vs. standing = 0.58 Mouse speed treadmill$_{1.6\ km/h}$ vs. standing = 0.34 Mouse speed cycling$_{5W}$ vs. standing = 0.21 Mouse speed treadmill$_{3.2\ km/h}$ vs. cycling$_{5W}$ = 0.34 Mouse speed treadmill$_{1.6\ km/h}$ vs. cycling$_{5W}$ = 0.13 Mouse speed treadmill$_{3.2\ km/h}$ vs. cycling$_{30W}$ = 0.42
	Mouse task accuracy values: standing (0.1), treadmill$_{1.6\ km/h}$ (0.17), treadmill$_{3.2\ km/h}$ (0.2), cycling$_{5W}$ (0.13), cycling$_{30W}$ (0.16). Accuracy results showed an increase of error for the treadmill$_{1.6\ km/h}$, treadmill$_{3.2\ km/h}$ and cycling$_{30W}$ compared to standing. Also, results showed an increase in error for treadmill$_{3.2\ km/h}$ compared to cycling$_{5W}$. Mouse task perceived accuracy scores: standing (2.77), treadmill$_{1.6\ km/h}$ (3.63), treadmill$_{3.2\ km/h}$ (3.81), cycling$_{5W}$ (3.18), cycling$_{30W}$ (3.39). Scores showed a decrease of speed perception for treadmill$_{1.6\ km/h}$, treadmill$_{3.2\ km/h}$, cycling$_{5W}$ and cycling$_{30W}$ compared to standing. Also, results showed a decrease in speed perception for treadmill$_{1.6\ km/h}$ and treadmill$_{3.2\ km/h}$ compared to cycling$_{5W}$.	Mouse perceived speed treadmill$_{3.2\ km/h}$ vs. standing = 0.93 Mouse perceived speed treadmill$_{1.6\ km/h}$ vs. standing = 1.04 Mouse perceived speed cycling$_{5W}$ vs. standing = 0.67 Mouse perceived speed cycling$_{30W}$ vs. standing = 0.73 Mouse perceived speed treadmill$_{3.2\ km/h}$ vs. cycling$_{5W}$ = 0.41 Mouse perceived speed treadmill$_{1.6\ km/h}$ vs. cycling$_{5W}$ = 0.31 Mouse perceived speed treadmill$_{3.2\ km/h}$ vs. cycling$_{30W}$ = 0.32 Mouse perceived speed treadmill$_{1.6\ km/h}$ vs. cycling$_{30W}$ = 0.23

Combined keyboard and mouse task speed values: standing (11.94), treadmill$_{1.6\ \text{km/h}}$ (9.57), treadmill$_{3.2\ \text{km/h}}$ (8.26), cycling$_{5W}$ (10.84), cycling$_{30W}$ (11.17).
Results showed a decrease of task speed for treadmill$_{1.6\ \text{km/h}}$ and treadmill$_{3.2\ \text{km/h}}$ compared to standing. Also, results showed a decrease in task speed for treadmill$_{3.2\ \text{km/h}}$ and treadmill$_{1.6\ \text{km/h}}$ compared to cycling$_{5W}$ and cycling$_{30w}$.

Combined keyboard and mouse task perceived speed scores: standing (2.99), treadmill$_{1.6\ \text{km/h}}$ (3.7), treadmill$_{3.2\ \text{km/h}}$ (4.08), cycling$_{5W}$ (3.51), cycling$_{30W}$ (3.52). Scores showed a decrease in the perception of speed for treadmill$_{1.6\ \text{km/h}}$, treadmill$_{3.2\ \text{km/h}}$, cycling$_{5W}$ and cycling$_{30W}$ compared to standing. Also, scores showed a decrease in the perception of speed for treadmill$_{1.6\ \text{km/h}}$ and treadmill$_{3.2\ \text{km/h}}$ compared to cycling$_{5W}$ and cycling$_{30W}$.

Combined keyboard and mouse perceived accuracy scores: standing (2.95), treadmill$_{1.6\ \text{km/h}}$ (3.79), treadmill$_{3.2\ \text{km/h}}$ (4.04), cycling$_{5W}$ (3.38), cycling$_{30W}$ (3.48). Scores showed a decrease in the perception of accuracy for treadmill$_{1.6\ \text{km/h}}$ and treadmill$_{3.2\ \text{km/h}}$ compared to cycling$_{5W}$ and cycling$_{30W}$. Scores also showed a decrease in the perception of accuracy for treadmill$_{3.2\ \text{km/h}}$ and compared to treadmill$_{1.6\ \text{km/h},}$ cycling$_{5W}$ and cycling$_{30W}$.

Heart rate means values: standing (82), treadmill$_{1.6\ \text{km/h}}$ (82), treadmill$_{3.2\ \text{km/h}}$ (87), cycling$_{5W}$ (79), cycling$_{30W}$ (89). Results showed an increase in the mean heart rate for standing, treadmill$_{1.6\ \text{km/h}}$, treadmill$_{3.2\ \text{km/h}}$, and cycling$_{30W}$ compared to cycling$_{5W}$. Results also showed an increase in mean heart rate for treadmill$_{3.2\ \text{km/h}}$ and cycling$_{30W}$ compared to standing.

Perceived exertion scores: standing (0.95), treadmill$_{1.6\ \text{km/h}}$ (1.74), treadmill$_{3.2\ \text{km/h}}$ (2.39), cycling$_{5W}$ (1.66), cycling$_{30W}$ (2.61). Perceived exertion scores showed an increase for treadmill$_{1.6\ \text{km/h}}$, treadmill$_{3.2\ \text{km/h}}$, cycling$_{5W}$ and cycling$_{30W}$

Mouse task accuracy treadmill$_{3.2\ \text{km/h}}$ vs. standing = 0.39
Mouse task accuracy treadmill$_{1.6\ \text{km/h}}$ vs. standing = 0.26
Mouse task accuracy cycling$_{30W}$ vs. standing = 0.25
Mouse task accuracy treadmill$_{3.2\ \text{km/h}}$ vs. cycling$_{5W}$ = 0.24
Mouse perceived accuracy treadmill$_{3.2\ \text{km/h}}$ vs. standing = 1.09
Mouse perceived accuracy treadmill$_{1.6\ \text{km/h}}$ vs. standing = 0.82
Mouse perceived accuracy cycling$_{5W}$ vs. standing = 0.43
Mouse perceived accuracy cycling$_{30W}$ vs. standing = 0.65
Mouse perceived accuracy treadmill$_{3.2\ \text{km/h}}$ vs. cycling$_{5W}$ = 0.47
Mouse perceived accuracy treadmill$_{3.2\ \text{km/h}}$ vs. cycling$_{5W}$ = 0.76

Combined keyboard-mouse speed treadmill$_{3.2\ \text{km/h}}$ vs. standing = -0.26
Combined keyboard-mouse speed treadmill$_{1.6\ \text{km/h}}$ vs. standing = -0.41
Combined keyboard-mouse speed treadmill$_{3.2\ \text{km/h}}$ vs. cycling$_{5W}$ = -0.28
Combined keyboard-mouse speed treadmill$_{1.6\ \text{km/h}}$ vs. cycling$_{5W}$ = -0.13
Combined keyboard-mouse speed treadmill$_{3.2\ \text{km/h}}$ vs. cycling$_{30W}$ = -1.53
Combined keyboard-mouse speed treadmill$_{1.6\ \text{km/h}}$ vs. cycling$_{30W}$ = -1.36

compared to standing. Also, scores showed an increase of perceived exertion for treadmill$_{3.2 \text{ km/h}}$ and cycling$_{30W}$ compared to treadmill$_{1.6 \text{ km/h}}$ and an increase of perceived exertion for treadmill$_{3.2 \text{ km/h}}$ and cycling$_{30W}$ compared to cycling$_{5W}$. All other results were non-significant.	Combined keyboard-mouse perceived speed treadmill$_{3.2 \text{ km/h}}$ vs. standing = 1.10 Combined keyboard-mouse perceived speed treadmill$_{1.6 \text{ km/h}}$ vs. standing = 0.60 Combined keyboard-mouse perceived speed cycling$_{5W}$ vs. standing = 0.47 Combined keyboard-mouse perceived speed cycling$_{30W}$ vs. standing = 0.55 Combined keyboard-mouse perceived speed treadmill$_{3.2 \text{ km/h}}$ vs. cycling$_{5W}$ = 0.51 Combined keyboard-mouse perceived speed treadmill$_{1.6 \text{ km/h}}$ vs. cycling$_{5W}$ = 0.15 Combined keyboard-mouse perceived speed treadmill$_{3.2 \text{ km/h}}$ vs. cycling$_{30W}$ = 0.58 Combined keyboard-mouse perceived speed treadmill$_{1.6 \text{ km/h}}$ vs. cycling$_{30W}$ = 0.15 Combined keyboard-mouse perceived accuracy treadmill$_{3.2 \text{ km/h}}$ vs. standing = 3.32 Combined keyboard-mouse perceived accuracy treadmill$_{1.6 \text{ km/h}}$ vs. standing = 2.43 Combined keyboard-mouse perceived accuracy cycling$_{5W}$ vs. standing = 1.31 Combined keyboard-mouse perceived accuracy cycling$_{30W}$ vs. standing = 1.57

Combined keyboard-mouse perceived accuracy treadmill$_{\text{3.2 k m/h}}$ vs. treadmill$_{\text{1.6 k m/h}}$ = 0.64

Combined keyboard-mouse perceived accuracy treadmill$_{\text{3.2 k m/h}}$ vs. cycling$_{\text{5W}}$ = 1.75

Combined keyboard-mouse perceived accuracy treadmill$_{\text{3.2 k m/h}}$ vs. cycling$_{\text{30W}}$ = 1.45

Heart rate treadmill$_{\text{3.2 k m/h}}$ vs. standing = 0.22

Heart rate cycling$_{\text{30W m/h}}$ vs. standing = 0.31

Heart rate treadmill$_{\text{3.2 k m/h}}$ vs. treadmill$_{\text{1.6 k m/h}}$ = 0.22

Heart rate cycling$_{\text{30W m/h}}$ vs. treadmill$_{\text{1.6 k m/h}}$ = 0.31

Heart rate treadmill$_{\text{3.2 k m/h}}$ vs. cycling$_{\text{5W}}$ = 0.37

Heart rate treadmill$_{\text{1.6 k m/h}}$ vs. cycling$_{\text{5W}}$ = 0.15

Heart rate cycling$_{\text{30W m/h}}$ vs. cycling$_{\text{5W}}$ = 0.47

Perceived exertion treadmill$_{\text{3.2 k m/h}}$ vs. standing = 0.56

Perceived exertion treadmill$_{\text{1.6 k m/h}}$ vs. standing = 0.33

Perceived exertion cycling$_{\text{5w}}$ vs. standing = 0.29

Perceived exertion cycling$_{\text{30w}}$ vs. standing = 0.66

Perceived exertion treadmill$_{\text{3.2 k m/h}}$ vs. treadmill$_{\text{1.6 k m/h}}$ = 0.65

Perceived exertion cycling$_{\text{30w}}$ vs. treadmill$_{\text{1.6 k m/h}}$ = 0.87

								Perceived exertion treadmill$_{3.2\ k\ m/h}$ vs. cycling$_{5w}$ = 0.25 Perceived exertion cycling$_{30w}$ vs. cycling$_{5w}$ = 0.34
Tronarp, et al. [16]	Randomized crossover	Standing session of 30 minutes Cycling$_{20\%MAP}$ session of 75 minutes Cycling $_{50\%MAP}$ session of 30 minutes	Males = 15 Females = 21	26.8 years old Healthy adults	Standing Cycling (20%MAP) Cycling (50%MAP)	Pressure pain threshold Thermal pain threshold Typing gross speed (included errors; word/min) Typing net speed (excluded errors; word/min) Typing accuracy Mouse successful task Mouse speed to complete task Stroop colour word test (% of correct word) Energy expenditure	Typing gross speed values: Standing (47), cycling$_{20\%MAP}$ (46.5), cycling$_{50\%MAP}$ (45.5). Typing gross speed was reduced for cycling$_{50\%MAP}$ and cycling$_{20\%MPA}$ compared to standing. Typing net speed values: standing (46.3), cycling$_{20\%MAP}$ (44.3), cycling$_{50\%MAP}$ (43.8). Typing net speed was reduced for cycling$_{50\%MAP}$ and cycling$_{20\%MAP}$ compared to standing. Typing errors values: standing (13.8), cycling$_{20\%MAP}$ (16.3), cycling$_{50\%MAP}$ (20.0). Typing errors improved with cycling$_{50\%MAP}$ and cycling$_{20\%MAP}$ compared to standing. Mouse pointing successful task values: standing (7), cycling$_{20\%MAP}$ (5.5), cycling$_{50\%MAP}$ (3.5). Accuracy was reduced during both cycling$_{50\%MAP}$ and cycling$_{20\%MAP}$ compared to standing, as well as in cycling$_{50\%MAP}$ compared to cycling$_{20\%MAP}$. Mouse speed values: standing (33.6), cycling$_{20\%MAP}$ (32.6), cycling$_{50\%MAP}$(33.9). Mouse speed was reduced for standing compared to cycling$_{20\%MAP}$ and a for cycling$_{50\%MAP}$ compared to standing (33.6 sec). Energy expenditure median values (kcal/min): standing (1.4), cycling$_{20\%MAP}$ (3.3), cycling$_{50\%MAP}$ (7.5). Energy expenditure increased for cycling$_{50\%MAP}$ and cycling$_{20\%MAP}$ compared to standing. It also increased for cycling$_{50\%MAP}$ compared to cycling$_{20\%MAP}$. All other results were non-significant.	Missing data

Zeigler, et al. [8]	Randomized crossover full-factorial	Monitoring for 12 hours (08h00-20h00). Analysed hours: 1) 12 hours (08h00-20h00) 2) Work hours (08h00-16h00) with bout of active workstation for a cumulative of 2.5 hours 3) Post work hours (16h00-20h00)	Males = 2 Females = 7	30 years old BMI=28.7 kg/m^2 Pre- hypertensive (N = 7)	Siting Standing Treadmill (1.6 km/h) Cycling (20W at 25-20 RPM)	Heart rate Blood pressure	12 hour periods' (08h00- 20h00) mean heart rate values: standing (74 ± 12), treadmill$_{1.6\ km/h}$ (78 ± 12), cycling$_{20W}$ (78 ± 13). Treadmill$_{1.6\ km/h}$ and cycling$_{20W}$ increased heart rate compared to standing. 12 hours' mean SBP values: standing (132 ± 17), treadmill$_{1.6\ km/h}$(133 ± 17), cycling$_{20W}$ (130 ± 16). Cycling$_{20W}$ and treadmill$_{1.6\ km/h}$ lowered SBP compared to standing. Cycling$_{20W}$ lowered SBP compared to treadmill$_{1.6\ km/h}$. 12 hours's means DBP values: standing (72 ± 12), treadmill$_{1.6\ km/h}$(71 ± 17), cycling$_{20W}$(69 ± 16). Cycling$_{20W}$ lowered DBP compared to treadmill$_{1.6\ km/h}$ and standing. Work hours' heart rate values: standing (72±12), treadmill$_{1.6\ km/h}$(77 ± 13), cycling$_{20W}$ (78 ± 14). Cycling$_{20W}$ and Treadmill$_{1.6\ km/h}$ increased heart rate compared to standing. Work hours' SBP mean values: standing (131 ± 16), treadmill$_{1.6\ km/h}$(131 ± 16), cycling$_{20W}$ (129 ± 15). Cycling$_{20W}$ lowered SBP compared to treadmill$_{1.6\ km/h}$ and standing. Work hours' DBP mean values: standing (74 ± 11), treadmill$_{1.6\ km/h}$(73 ± 11), cycling$_{20W}$ (71 ± 11). Cycling$_{20W}$ lowered DBP compared to standing. Post work hours' SPB mean values: standing (134 ± 18), treadmill$_{1.6\ km/h}$ (135 ± 17), cycling$_{20W}$ (127 ± 15). Cycling$_{20W}$ lowered SBP compared to treadmill$_{1.6\ km/h}$ and standing.	Heart rate (08h00-20h00) treadmill$_{1.6\ km/h}$vs. standing = 0.33 Heart rate (08h00-20h00) cycling$_{20W}$ vs. standing = 0.33 SBP (08h00-20h00) treadmill$_{1.6\ km/h}$vs. standing = 0.06 SBP (08h00-20h00) cycling$_{20W}$ vs. standing = -0.12 SBP (08h00-20h00) cycling$_{20W}$ vs. treadmill$_{1.6\ km/h}$ = -0.18 DBP (08h00-20h00) cycling$_{20W}$ vs. treadmill$_{1.6\ km/h}$ = -0.12 Heart rate (work hours) 20h00) treadmill$_{1.6\ km/h}$ vs. standing = 0.4 Heart rate (work hours) cycling$_{20W}$ vs. standing = 0.33 SBP (work hours) cycling$_{20W}$ vs. standing = -0.13 SBP (work hours) cycling$_{20W}$ vs. treadmill$_{1.6\ km/h}$ = -0.13 DBP (work hours) cycling$_{20W}$ vs. standing = -0.27 SBP (post work) cycling$_{20W}$ vs. standing = -0.42

LEGEND: BMI= Body mass index EGG= electroencephalography, EMG=Electromyography, FMD= Flow-mediated dilation, MAP= % of maximum aerobic power, SBP= Systolic blood pressure, DBP= Diastolic blood pressure, RPM= revolutions per minute, W=Watts, %MVC=maximum voluntary contractions, %g= gravitational force.

Values presented are means, unless otherwise specified.

Table 3:

Study quality assessed by the Modified Down and Black checklist

Item:	**Criteria:**	**Score:**											
		Bantoft, et al.[21]	Botter, et al.[13]	Commissaris, et al.[25]	Cox, et al.[14]	Gilson, et al.[18]	Kruse, et al.[17]	Ohlinger, et al.[20]	Mullane, et al.[19]	Sliter and Yuan[10]	Straker, et al.[115]	Tronarp, et al.[16]	Zeigler, et al.[8]
Reporting													
1	*Is the hypothesis/aim/objective of the study clearly described?*	1	1	1	1	1	1	1	1	1	1	1	1
2	*Are the main outcomes to be measured clearly described in the Introduction or?* *Methods section?*	1	1	1	1	1	1	1	1	1	1	1	1
3	*Are the characteristics of the patients included in the study clearly described?*	1	1	1	1	1	1	1	1	1	1	1	1
4	*Are the interventions of interest clearly described?*	1	1	1	1	1	1	1	1	1	1	1	1
5	*Are the distributions of principal confounders in each group of subjects to be compared clearly described?*	2	0	2	0	1	2	2	2	0	1	1	2
6	*Are the main findings of the study clearly described?*	1	1	1	1	1	1	1	1	1	1	1	1
7	*Does the study provide estimates of the random variability in the data for the main outcomes?*	1	1	1	1	1	1	1	1	1	1	1	1
8	*Have all important adverse events that may be a consequence of the intervention been reported?*	1	0	1	0	0	1	1	1	0	0	0	0
9	*Have the characteristics of patients lost to follow-up been described?*	0	0	0	0	1	0	0	1	1	0	1	1
10	*Have actual probability values been reported (e.g. 0.035 rather than <0.05) for the main outcomes except where the probability value is less than 0.001?*	1	1	1	1	1	1	1	1	1	1	1	1
External validity													
11	*Were the subjects asked to participate in the study representative of the entire population from which they were recruited?*	1	1	0	0	0	0	1	0	1	1	1	1
12	Were those subjects who were prepared to participate representative of the entire population from which they were recruited?	1	1	0	0	0	0	1	0	0	0	1	1
13	*Were the staff, places, and facilities where the patients were treated, representative of the treatment the majority of patients receive?*	0	0	1	0	0	0	0	0	0	0	0	0
Internal validity - bias													
14	*Was an attempt made to blind study subjects to the intervention they have received?*	0	0	0	0	0	0	0	0	0	0	0	0
15	*Was an attempt made to blind those measuring the main outcomes of the intervention?*	0	0	0	1	0	0	0	0	0	0	0	0
16	*If any of the results of the study were based on "data dredging", was this made clear?*	1	1	1	1	1	1	1	1	1	1	1	1
17	*In trials and cohort studies, do the analyses adjust for different lengths of follow-up of patients, or in case-control studies, is the time period between the intervention and outcome the same for cases and controls?*	1	0	1	1	1	1	1	1	1	1	1	1
18	*Were the statistical tests used to assess the main outcomes appropriate?*	1	1	1	1	1	1	1	1	1	1	1	1
19	*Was compliance with the intervention/s reliable?*	1	1	1	1	1	1	1	1	1	1	1	1
20	*Were the main outcome measures used accurate (valid and reliable)?*	1	1	1	1	1	1	1	1	1	1	1	1
Internal validity – confounding (selection bias)													

21	*Were the patients in different intervention groups (trials and cohort studies) or were the cases and controls (case-control studies) recruited from the same population?*	1	1	0	0	0	0	1	0	1	1	1	0
22	*Were study subjects in different intervention groups (trials and cohort studies) or were the cases and controls (case-control studies) recruited over the same period of time?*	0	0	0	0	0	0	0	0	0	0	0	0
23	*Were study subjects randomized to intervention groups?*	1	1	1	1	1	0	1	1	0	0	1	1
24	*Was the randomized intervention assignment concealed from both patients and health care staff until recruitment was complete and irrevocable?*	0	0	0	0	0	0	0	0	0	0	0	0
25	*Was there adequate adjustment for confounding in the analyses from which the main findings were drawn?*	1	0	0	0	0	1	0	1	0	0	1	0
26	*Were losses of patients to follow-up taken into account?*	0	1	0	0	1	0	0	1	1	0	1	1
Power													
27*	*Did the study have sufficient power to detect a clinically important effect where the probability value for a difference being due to chance is less than 5%? Sample sizes have been calculated to detect a difference of x% and y%.*	0	0	0	0	0	0	1	0	1	0	1	0
TOTAL SCORE		19/28	16/28	17/28	14/28	16/28	16/28	20/28	19/28	17/28	15/28	21/28	19/28
**item has been modified “yes” =1; “no”=0*													

Musculoskeletal Activity

One study[13] examined the biomechanics of three active workstations using electromyography of the trapezius and erector spinae, trunk and head 3D kinematics, and physical activity quantified by accelerometers on the legs, trunk and arms. Twelve participants were asked to complete general office tasks (i.e. typing, reading, correction, telephone use, mouse dexterity, and cognitive tasks) while using active workstations. An increase in right trapezius activity was observed from standing to $\text{treadmill}_{2.5\ \text{km/h}}$ workstations: 3.8% *versus* 8.1% of maximum voluntary contraction (median values), respectively. Also, all variables concerning the intensity of movement (median and 95th percentile) increased in $\text{treadmill}_{0.6\ \text{km/h}}$ and $\text{treadmill}_{2.5\ \text{km/h}}$ conditions compared to standing, except for the physical activity intensity of the head at the 95th percentile for $\text{treadmill}_{0.6\ \text{km/h}}$ which remained similar to the standing condition.

Physiological Activity

Six studies[8 13-17] reported physiological outcomes. Four[13-16] included adults with no health issues (N=109) and two studies[8 17] included adults with overweight or class 1 obesity who also had prehypertension or impaired fasting glucose (N=22). From those four studies, mean heart rate, blood pressure, energy expenditure, perceived exertion and pressure pain thresholds were assessed. All studies except one[17] showed no difference between workstations.

Mean Heart Rate

Increased heart rate (HR) was observed in all four studies[8 13-15] when using treadmill or cycling compared to standing workstations. Specifically, Botter, et al. [13] reported an increase of 12 beats per minute (bpm) using a $\text{treadmill}_{2.5\ \text{km/h}}$ (91 bpm) compared to standing (79 bpm), which was corroborated by Cox, et al. [14]. Moreover, Straker, et al. [15] reported an increase of 5 bmp for the $\text{treadmill}_{3.2\ \text{km/h}}$ and an increase of 7 bmp for $\text{cycling}_{30\text{W}}$ compared to standing workstations. All other conditions with lower power or speed (e.g. $\text{treadmill}_{1.6\ \text{km/h}}$; $\text{cycling}_{5\text{W}}$) did not result in an increase in bmp. Zeigler, et al. [8] monitored HR during a 12-hour period

(08h00 – 20h00) and were specifically interested in two periods [i.e. work hours (08h00 – 16h00) and post-work hours (16h00 – 20h00)]. Results from the 12-hour period showed an increase of 4 bpm for both $\text{treadmill}_{1.6\ \text{km/h}}$ and $\text{cycling}_{20\text{W}}$ conditions compared to standing. Results from the working hour-specific period showed an increase of 5 bpm for $\text{treadmill}_{1.6\ \text{km/h}}$ and 6 bpm for $\text{cycling}_{20\text{w}}$ compared to standing. Results from post-work period showed no difference in HR between conditions.

Blood Pressure

Two studies[8] [14] with different populations and active workstations examined mean systolic blood pressure (SBP) and mean diastolic blood pressure (DBP). Cox, et al. [14] found no difference in SBP and DBP measured during an intervention comparing standing and treadmill workstations. The second study[8] monitored ambulatory blood pressure on adults with overweight or class 1 obesity meeting prehypertensive or impaired fasting glucose criteria over a 12-hour period (08h00 — 20h00). During the 12-hour period, a reduction of 2 mmHg for $\text{cycling}_{20\text{w}}$ and 1 mmHg for $\text{treadmill}_{1.6\ \text{km/h}}$ was reported in SBP compared to standing. For the work-hour period (08h00—16h00), a decrease in SBP of 2 mmHg was reported for $\text{cycling}_{20\text{W}}$ compared for both $\text{treadmill}_{1.6\ \text{km/h}}$ and standing workstations. In the post-work period (16h00—20h00), there was a greater decrease in SPB compared to the two periods mentioned above. SBP for $\text{cycling}_{20\text{W}}$ decreased by 8 mmHg compared to $\text{treadmill}_{1.6\ \text{km/h}}$ and 9 mmHg compared to the standing workstation. DBP was similar between standing and $\text{treadmill}_{1.6\ \text{km/h}}$ conditions for all three periods. However, $\text{cycling}_{20\text{W}}$ decreased DBP by 3 mmHg compared to standing, and 2 mmHg compared to $\text{treadmill}_{1.6\text{km/h}}$ workstations for the 12-hour period as well as decreased DBP by 3 mmHg compared to standing during working hours.

Energy Expenditure

Energy expenditure and VO_2 were measured in three studies.[13] [14] [16] Botter, et al. [13] showed an increase in energy expenditure of 1.2 MET for $\text{treadmill}_{2.5\ \text{km/h}}$ workstations compared to standing. Cox, et al. [14] measured a similar increase of 1 MET from standing to $\text{treadmill}_{1.61\ \text{km/h}}$. Tronarp, et al. [16] measured energy expenditure in kcal. In this study, energy expenditure increased between all three conditions: an increase of 2.9 kcal/min between cycling$_{20\%MAP}$ and standing; an increase of 6.9 kcal/min between cycling$_{50\%MAP}$ and standing.

Perceived Exertion and Pain Tolerance

Two studies14 15 measured perceived exertion, both using the 10-point Borg Scale. The first study, Cox, et al. 14 reported an increase in perceived effort and perceived breathlessness (i.e. dyspnea) on the treadmill compared to standing for all tasks, namely warm-up, silent reading, reading aloud, and speaking aloud spontaneously. The second study15 reported higher perceived exertion for treadmill1.6 km/h (1.74/10), treadmill3.2 km/h (2.39/10), cycling5W (1.66/10), and cycling30W (2.61/10) compared to standing (0.95/10). Furthermore, higher perceived exertion was reported for greater power and speed on treadmill and cycling workstations (e.g. treadmill3.2 km/h and cycling30W compared to treadmill1.6 km/h and cycling5W).

Pressure pain threshold was measured in kilopascals (kPa) using a Somedic algometer on the right quadriceps, right ventral forearm and right trapezius.16 Only differences in the pressure pain threshold of the right trapezius between standing (16.8 kPa) and cycling20%MAP (39.3 kPa) were reported.

Work Performance

Seven studies[10 15 16 18-21] reported cognitive outcomes. The authors measured perceived and actual task performances (e.g. typing, mouse, psychomotor performances), attention and short-term memory capacity as well as psychobiological (e.g. arousal, boredom) outcomes.

Perceived Work Performance

One study[15] reported perceived task performance. Studies observed perceived speed and accuracy of typing, mouse pointing and combined keyboard/mouse tasks. Perceived work performance was assessed with a questionnaire. Participants rated perceived effect of the use of diverse active workstations on a scale of 1 to 5 (i.e. 1 = very enhanced to 5 = very diminished). Results from the perceived typing questionnaire showed a decrease in performance for the treadmill$_{1.6\ \text{km/h}}$, treadmill$_{3.2\ \text{km/h}}$, cycling$_{5\text{W}}$, and cycling$_{30\text{W}}$ compared to standing. Perceived accuracy also decreased with the use of both treadmill$_{1.6\text{-}3.2\ \text{km/h}}$ and cycling$_{5\text{-}30\text{W}}$ workstations compared to the standing workstation. In addition, a decline in perceived accuracy was reported for the low intensity treadmill$_{1.6\ \text{km/h}}$ compared to the low intensity cycling$_{5\text{W}}$ condition.

Questionnaire outcomes for perceived mouse pointing speed showed a decrease for treadmill$_{1.6\ \text{km/h}}$, treadmill$_{3.2\ \text{km/h}}$, cycling$_{5\text{W}}$, and cycling$_{30\text{W}}$ compared to standing. Also, a reduction of perceived speed was observed for both treadmill$_{1.6\text{km/h}}$ and treadmill$_{3.2\ \text{km/h}}$ compared to both cycling$_{5\text{W}}$ and cycling$_{30\text{W}}$ conditions. There was a decline for the treadmill$_{1.6\ \text{km/h}}$, treadmill$_{3.2\ \text{km/h}}$, cycling$_{5\text{W}}$, and cycling$_{30\text{W}}$ compared to standing in perceived mouse pointing accuracy. There was a reduction in perceived accuracy for both treadmill workstations compared to low intensity cycling$_{5\text{W}}$.

Questionnaire outcomes for perceived combined keyboard/mouse speed tasks showed a decrease in perceived speed for treadmill$_{1.6\ \text{km/h}}$, treadmill$_{3.2\ \text{km/h}}$, cycling$_{5\text{W}}$, and cycling$_{30\text{W}}$ compared to standing. In addition, a decline in perceived speed for both treadmill workstation conditions compared to both cycling workstation conditions was observed. Perceived accuracy decreased for the treadmill$_{1.6\ \text{km/h}}$, treadmill$_{3.2\ \text{km/h}}$, cycling$_{5\text{W}}$, and cycling$_{30\text{W}}$ compared to standing. Moreover, perceived accuracy declined for treadmill$_{3.2\ \text{km/h}}$ compared to the lower intensity treadmill$_{1.6\ \text{km/h}}$ and both cycling workstation conditions.

Actual Performance Tasks

Three studies[15 16 20] examined the effect of active workstations on typing performance. Straker, et al.[15] examined the effect of active workstations on typing speed performance (words/min) and accuracy (% of typing errors). Typing speed was reduced for the treadmill$_{3.2\ \text{km/h}}$ (49.73 words/min), treadmill$_{1.6\ \text{km/h}}$ (50.14 words/min), cycling$_{5\text{W}}$ (53.17 words/min) and cycling$_{30\text{W}}$ (52.58 words/min) compared to standing (54.09 words/min). No differences were reported for the accuracy test. Tronarp, et al. [16] found that gross speed (i.e. including erased typing errors) was reduced for the cycling$_{50\%\text{MAP}}$ (45.5 words/min) and cycling$_{20\%\text{MPA}}$ (46.5 words/min) compared to standing (47.0 words/min). Net speed (i.e.

excluding erased typing errors) was also reduced for cycling$_{50\%MAP}$ (43.8 words/min) and cycling$_{20\%MAP}$ (44.3 words/min) compared to standing (46.3 words/min). Moreover, typing errors (i.e. # of errors) increased with both cycling$_{50\%MAP}$ (20) and cycling$_{20\%MAP}$ (16.3) compared to standing (13.8). No differences were reported between cycling$_{50\%MAP}$ and cycling$_{20\%MAP}$. Ohlinger, et al. [20] measured the number of taps in a 10-second trial. A reduction in taping speed was observed for the treadmill workstation (55.8) compared to the standing workstation (57.0). To resume, all three studies observed decreases in typing speed with treadmill workstations compared to a standing workstation. The two studies[15][16] with cycling conditions observed a decreases in typing speed compared to a standing workstation. Only one study[16] observed a decrease in typing word accuracy with the use of cycling workstations compared to a standing workstation.

Two studies[15][16] examined mouse pointing speed (i.e. milliseconds) and accuracy (i.e. actual errors). The first study[15] reported a decrease in speed for treadmill$_{1.6\ km/h}$ (1059 ms); treadmill$_{3.2\ km/h}$ (1107 ms); and cycling$_{5W}$ (1022 ms) compared to standing (959 ms). Similar values were reported for cycling$_{5W}$ and cycling$_{30W}$ workstations (1022 ms). Both treadmill$_{1.6\ km/h-3.2\ km/h}$ workstations resulted in decreased mouse pointing speed compared to both cycling$_{5W-30W}$ workstations. Furthermore, pointing error increased using treadmill$_{1.6km/h}$ (0.17), treadmill$_{3.2km/h}$ (0.20) and cycling$_{30W}$ (0.16) compared to standing (0.10), and for treadmill$_{3.2\ km/h}$ (0.20) compared to cycling$_{5W}$ (0.13). To resume this study observed that mouse pointing speed and accuracy decreased with treadmill workstations compared to a standing workstation. In addition, mouse pointing speed decreased with the use of treadmill workstations compared to cycling workstations. The second study[16] reported a decrease in mouse pointing speed for standing (33.6 ms) compared to cycling$_{20\%MAP}$ (32.6 ms). But contrary to the last study, a decrease in mouse pointing speed was reported for a higher cycling$_{50\%MAP}$ intensity (33.9 ms) compared to standing (33.6 ms). Accuracy was assessed by the number of successful tasks. Results showed a reduction of successful tasks during both cycling$_{50\%MAP}$ (3.5) and cycling$_{20\%MAP}$ (5.5) compared to standing (7), and a decrease in cycling$_{50\%MAP}$ (3.5) compared to cycling$_{20\%MAP}$ (5.5).

One study[15] examined combined keyboard and mouse task performance (i.e. speed [words/s] and error rate). A decrease in speed was observed for both treadmill$_{1.6km/h}$ (9.57 words/s) and treadmill$_{3.2\ km/h}$ (8.26 words/s) compared to standing (11.94 words/s). Furthermore, a decrease in speed was observed for the treadmill$_{1.6km/h}$ (9.57words/s) and treadmill$_{3.2\ km/h}$ (8.26 words/s) conditions compared to the cycling$_{5W}$ (10.84words/s) and cycling$_{30W}$ (11.17 words/s) conditions. No differences in error rate were reported between active workstations.

Processing Speed Tasks

Processing speed tasks were assessed in one study.[19] Researchers used a psychomotor test (i.e. detection test from Cogstate) to measure speed and reaction time to accomplish a simple task. Standing z-score and treadmill$_{1.6\ km/h}$ z-score showed a lower speed of performance than cycling$_{20W}$ z-score. Cycling$_{20W}$ reaction time was faster than standing reaction time.

Attention and Short Memory

Out of the four studies[18-21] that examined the influence of active workstations on attention and short-term memory capacity, none found differences between active workstations (i.e. standing, treadmill and cycling) in selective attention. Moreover, divided attention and short-term auditory verbal memory revealed no differences between standing, treadmill and cycling workstations.

Psychobiological

One study[10] reported psychobiological outcomes. With a 4-rating scale questionnaire, this study evaluated the level of arousal, boredom, stress, and task satisfaction (e.g. 1 = definitely no to 4 = definitely yes). The authors reported that treadmill workstations increased arousal compared to standing as well as cycling compared to standing. Boredom decreased with treadmill and cycling workstations compared to standing. Stress scores showed that treadmill workstations lowered stress compared to standing.

Discussion

The purpose of this review article was to compare the benefits between standing, treadmill and cycling workstations. This article reviewed 12 studies. Our main findings were that: 1) The benefits associated with standing, treadmill, and cycling workstation may not be equivalent; 2) Cycling and treadmill workstations appear to provide greater short-term physiologic changes than standing workstations that could potentially lead to better health; and 3) Cycling, treadmill and standing workstations appear to show productivity benefits while treadmill workstations seem to diminish the performance of work-related use of computers.

Cycling Workstation

Cycling workstations with resistance (i.e. 20–30 W) can increase energy expenditure by twice the amount of MET compared to standing workstations.[13] Likewise, related to energy expenditure, HR could be increased by 10% compared to standing workstations.[13] [15] Also pertinent, one study reported that cycling workstations with the same HR and energy expenditure as treadmill workstations, produced a greater decrease in ambulatory blood pressure in adults presenting with obesity and a prehypertension.[8] Moreover, cycling was the only active workstation that decreased DBP. Although cardiometabolic benefits accompany 20–30 W of resistance, a lower intensity (i.e. 5 W) does not provide any advantages over standing or treadmill conditions.[15] Also, bouts of 10 min per hour using a cycling workstation are not enough to reverse the negative effects of prolonged sitting time on lower limb endothelial dysfunction.[17]

Cycling workstations increase arousal and reduce boredom significantly better than standing workstations.[10] These outcomes are relevant as research has reported an interaction between level of physical activity at work, well-being at work and work productivity.[22] [23] Furthermore, one study has proposed that cycling workstations could be capable of increasing short-term memory and attention more effectively than standing or treadmill workstations.[19]

No reductions in motor task performance were reported with the use of cycling workstations.[15] [24-27] Speed processing time in simple tasks do increase compared to treadmill and standing conditions.[19] [28] These productivity results are important as cycling workstations, compared to treadmill and standing workstations, allow workers to experience greater cardio-metabolic gains, while maintaining acceptable levels of productivity in office tasks.

Treadmill Workstation

Treadmill workstations with speeds between 1.6 km/h to 2.5 km/h raise energy expenditure by about 1 MET beyond standing workstations and the sedentary threshold (1.5 MET). Also, with greater intensity (i.e. 3.2 km/h), treadmill workstations can increase HR similar to what is found for cycling workstations at 30 W of resistance. However, at this speed, the increase in perceived exertion and discomfort decreases implementation feasibility and motor task performance. Furthermore, the use of treadmills compared to standing workstations decreases SBP while no difference is found for DBP.[8 14]

Compared to standing workstations, treadmill workstations can positively influence many psychological components related to the work environment. A reduction in task stress, an increase in arousal, a lower feeling of boredom, and a higher feeling of task satisfaction were reported by participants based on a single study.[10] More studies are required to clarify the effects of low-intensity exercise similar to the effects described for treadmill workstations on workers' mood. Some of these improvements may be explained by the increase in cardiovascular activity associated with an active workstation, possibly contributing to improved brain oxygenation, hence an improvement in cognitive tasks (memorization and attention).[11 29-33] However, the results of the current review did not provide evidence of any cognitive benefits from treadmill compared to cycling or standing workstations.

With treadmill workstations, executive motor task performance, such as typing, or mouse pointing was reduced.[15 25 34] Higher walking speeds (3.2 km/h) produced greater muscular activity in the upper limbs than that observed in standing or cycling workstations. This increase in muscular demand of the trunk muscles and upper limb muscles in order to stabilize posture and gait may affect motor coordination related to computer tasks[13 35] and could lead to muscular fatigue and muscle tension[13]. In this context, safety issues should be raised, and further studies are required to ensure the safety of workers using treadmill desks.

Standing Workstation

Several studies suggest that standing workstations can decrease sitting time at work.[6 33 36] As a result, even if standing workstations do not exceed a sedentary threshold (i.e. energy expenditure),[37] post-prandial glycaemia excursion and blood pressure[8 38 39] are improved compared to conventional seated workstations. It is known that prolonged sitting can potentially cause low back pain due to lumbar flexion. A standing position inhibits lumbar flexion. Periods of time on a standing workstation have shown to be preventive against such injuries at work.[9 40] Interestingly, contrary to a treadmill workstation, the upright posture from standing workstations does not alter executive office tasks such as typing and mouse pointing. Moreover, standing workstations do not increase perceived exertion or reduce the efficiency of computer tasks. Furthermore, studies suggest that globally, standing workstations do not alter cognitive performance tasks.[33 41]

Perspectives and Limits

Active workstations are a novel intervention. The comparison of active workstations was available in twelve studies and only eleven specifically compared outcomes between active workstations. Also, the findings of this literature review are supported by short-term measures only. In addition, a large number of outcomes were provided by only one or two studies which both had relatively small sample sizes. As mentioned by others authors42, larger randomised control trials with mid- and long-term protocols are needed to provide stronger evidence.

Conclusions

The benefits associated with standing, treadmill and cycling workstations may not be equivalent. Cycling and treadmill workstations appear to provide greater short-term physiologic improvements compared to standing, which could potentially lead to better health outcomes. Cycling, treadmill and standing workstations appear to show short-term productivity benefits; however, treadmill workstations reduce the performance of computer-related work.

With workers and the workplace slowly moving towards active workstations, future long-term studies integrating different types of active workstations should be conducted in order to provide additional evidence. Ultimately, workers and corporations should be able to critically examine the benefits and limitations of each type of workstation and determine which is most appropriate for the worker’s specific needs and tasks.

Acknowledgements

The authors wish to acknowledge the following individuals who contributed significant time and effort to the consensus development process and to the preparation of this manuscript: Denis Arvisais, Ryan Reid, Thiffya Arabi Kugathasan, Grant FIT24-health and productive work # 146019 initiative by Social Sciences and Humanities Research and Canadian Institutes of Health Research.

References

1. Ding D, Lawson KD, Kolbe-Alexander TL, et al. The economic burden of physical inactivity: a global analysis of major non-communicable diseases. *The Lancet*;388(10051):1311-24. doi: 10.1016/S0140-6736(16)30383-X
2. Choi B, Schnall PL, Yang H, et al. Sedentary work, low physical job demand, and obesity in US workers. *American Journal of Industrial Medicine* 2010;53(11):1088-101. doi: 10.1002/ajim.20886
3. Parry S, Straker L. The contribution of office work to sedentary behaviour associated risk. *BMC Public Health* 2013;13(1):296. doi: 10.1186/1471-2458-13-296
4. Chu AHY, Ng SHX, Tan CS, et al. A systematic review and meta-analysis of workplace intervention strategies to reduce sedentary time in white-collar workers. *Obesity Reviews* 2016;17(5):467-81. doi: 10.1111/obr.12388
5. Hutcheson AK, Piazza AJ, Knowlden AP. Work Site-Based Environmental Interventions to Reduce Sedentary Behavior: A Systematic Review. *American journal of health promotion : AJHP* 2018;32(1):32-47. doi: 10.1177/0890117116674681 [published Online First: 2016/10/27]
6. Neuhaus M, Eakin EG, Straker L, et al. Reducing occupational sedentary time: a systematic review and meta-analysis of evidence on activity-permissive workstations. *Obesity Reviews* 2014;15(10):822-38. doi: 10.1111/obr.12201
7. Tudor-Locke C, Schuna JM, Frensham LJ, et al. Changing the way we work: elevating energy expenditure with workstation alternatives. *Int J Obes* 2014;38(6):755-65. doi: 10.1038/ijo.2013.223
8. Zeigler ZS, Mullane SL, Crespo NC, et al. Effects of Standing and Light-Intensity Activity on Ambulatory Blood Pressure. *Med Sci Sports Exerc* 2016;48(2):175-81. doi: 10.1249/mss.0000000000000754 [published Online First: 2015/08/19]
9. Ognibene GT, Torres W, Von Eyben R, et al. Impact of a sit-stand workstation on chronic low back pain. *Journal of Occupational and Environmental Medicine* 2016;58(3):287-93.

10. Sliter M, Yuan Z. Workout at work: Laboratory test of psychological and performance outcomes of active workstations. *Journal of occupational health psychology* 2015;20(2):259-71.
11. Labonte-LeMoyne E, Santhanam R, Leger PM, et al. The delayed effect of treadmill desk usage on recall and attention. *Computers in Human Behavior* 2015;46:1-5. doi: 10.1016/j.chb.2014.12.054
12. Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *Journal of Epidemiology and Community Health* 1998;52(6):377.
13. Botter J, Ellegast RP, Burford EM, et al. Comparison of the postural and physiological effects of two dynamic workstations to conventional sitting and standing workstations. *Ergonomics* 2016;59(3):449-63. doi: 10.1080/00140139.2015.1080861 [published Online First: 2015/09/22]
14. Cox RH, Guth J, Siekemeyer L, et al. Metabolic cost and speech quality while using an active workstation. *Journal of Physical Activity and Health* 2011;8(3):332-39.
15. Straker L, Levine J, Campbell A. The effects of walking and cycling computer workstations on keyboard and mouse performance. *Human factors* 2009;51(6):831-44. doi: http://dx.doi.org/10.1177/0018720810362079
16. Tronarp R, Nyberg A, Hedlund M, et al. Office-Cycling: A Promising Way to Raise Pain Thresholds and Increase Metabolism with Minimal Compromising of Work Performance. *BioMed Research International* 2018;2018 (no pagination)(5427201) doi: http://dx.doi.org/10.1155/2018/5427201
17. Kruse NT, Hughes WE, Benzo RM, et al. Workplace Strategies to Prevent Sitting-induced Endothelial Dysfunction. *Med Sci Sports Exerc* 2017 doi: 10.1249/mss.0000000000001484 [published Online First: 2017/11/09]
18. Gilson ND, Hall C, Renton A, et al. Do Sitting, Standing or Treadmill Desks Impact Psychobiological Indicators of Work Productivity? *Journal of Physical Activity and Health* 2017;0(0):1-16. doi: 10.1123/jpah.2016-0712

19. Mullane SL, Buman MP, Zeigler ZS, et al. Acute effects on cognitive performance following bouts of standing and light-intensity physical activity in a simulated workplace environment. *J Sci Med Sport* 2017;20(5):489-93. doi: 10.1016/j.jsams.2016.09.015
20. Ohlinger CM, Horn TS, Berg WP, et al. The effect of active workstation use on measures of cognition, attention, and motor skill. *J Phys Act Health* 2011;8(1):119-25. [published Online First: 2011/02/08]
21. Bantoft C, Summers MJ, Tranent PJ, et al. Effect of Standing or Walking at a Workstation on Cognitive Function: A Randomized Counterbalanced Trial. *Hum Factors* 2016;58(1):140-9. doi: 10.1177/0018720815605446 [published Online First: 2015/09/27]
22. Michishita R, Jiang Y, Ariyoshi D, et al. The practice of active rest by workplace units improves personal relationships, mental health, and physical activity among workers. *Journal of Occupational Health* 2017;59(2):122-30.
23. Puig-Ribera A, Martínez-Lemos I, Giné-Garriga M, et al. Self-reported sitting time and physical activity: interactive associations with mental well-being and productivity in office employees. *BMC Public Health* 2015;15:72. doi: 10.1186/s12889-015-1447-5
24. Carr LJ, Maeda H, Luther B, et al. Acceptability and effects of a seated active workstation during sedentary work: A proof of concept study. *International Journal of Workplace Health Management* 2014;7(1):2-15. doi: http://dx.doi.org/10.1108/IJWHM-03-2013-0008
25. Commissaris DA, Konemann R, Hiemstra-van Mastrigt S, et al. Effects of a standing and three dynamic workstations on computer task performance and cognitive function tests. *Applied ergonomics* 2014;45(6):1570-8.
26. Elmer SJ, Martin JC. A cycling workstation to facilitate physical activity in office settings. *Applied Ergonomics* 2014;45(4):1240-46. doi: http://dx.doi.org/10.1016/j.apergo.2014.03.001
27. Cho J, Freivalds A, Rovniak LS. Utilizing anthropometric data to improve the usability of desk bikes, and influence of desk bikes on reading and typing performance. *Applied ergonomics* 2017;60:128-35. doi: 10.1016/j.apergo.2016.11.003

28. Torbeyns T, de Geus B, Bailey S, et al. Cycling on a Bike Desk Positively Influences Cognitive Performance. *PLoS ONE* 2016;11(11):e0165510. doi: 10.1371/journal.pone.0165510
29. Giles GEab, Brunye TTab, Eddy MDab, et al. Acute exercise increases oxygenated and deoxygenated hemoglobin in the prefrontal cortex. [Miscellaneous Article]: Neuroreport November 12, 2014;25(16):1320-1325 2014.
30. Ouchi Y, Okada H, Yoshikawa E, et al. Absolute Changes in Regional Cerebral Blood Flow in Association with Upright Posture in Humans: An Orthostatic PET Study. *Journal of Nuclear Medicine* 2001;42(5):707-12.
31. Rooks CR, Thom NJ, McCully KK, et al. Effects of incremental exercise on cerebral oxygenation measured by near-infrared spectroscopy: A systematic review. *Progress in Neurobiology* 2010;92(2):134-50. doi: http://dx.doi.org/10.1016/j.pneurobio.2010.06.002
32. Tomporowski PD. Effects of acute bouts of exercise on cognition. *Acta Psychologica* 2003;112(3):297-324. doi: http://dx.doi.org/10.1016/S0001-6918(02)00134-8
33. MacEwen BT, MacDonald DJ, Burr JF. A systematic review of standing and treadmill desks in the workplace. *Preventive Medicine* 2015;70:50-58. doi: https://doi.org/10.1016/j.ypmed.2014.11.011
34. Funk RE, Taylor ML, Creekmur CC, et al. Effect of walking speed on typing performance using an active workstation. *Perceptual and motor skills* 2012;115(1):309-18. doi: http://dx.doi.org/10.2466/06.23.26.PMS.115.4.309-318
35. Fedorowich LM, Emery K, Cote JN. The effect of walking while typing on neck/shoulder patterns. *European Journal of Applied Physiology* 2015;115(8):1813-23. doi: 10.1007/s00421-015-3163-3
36. Alkhajah TA, Reeves MM, Eakin EG, et al. Sit-stand workstations: A pilot intervention to reduce office sitting time. *American journal of preventive medicine* 2012;43(3):298-303.
37. Mansoubi M, Pearson N, Clemes SA, et al. Energy expenditure during common sitting and standing tasks: examining the 1.5 MET definition of sedentary behaviour. *BMC Public Health* 2015;15:516. doi: 10.1186/s12889-015-1851-x

38. Bouchard DR, Strachan S, Johnson L, et al. Using Shared Treadmill Workstations to Promote Less Time Spent in Daily Low Intensity Physical Activities: A Pilot Study. *J Phys Act Health* 2016;13(1):111-8. doi: 10.1123/jpah.2014-0451 [published Online First: 2015/04/02]

39. Buckley JP, Mellor DD, Morris M, et al. Standing-based office work shows encouraging signs of attenuating post-prandial glycaemic excursion. *Occupational and Environmental Medicine* 2014;71(2):109-11. doi: http://dx.doi.org/10.1136/oemed-2013-101823

40. Karakolis T, Barrett J, Callaghan JP. A comparison of trunk biomechanics, musculoskeletal discomfort and productivity during simulated sit-stand office work. *Ergonomics* 2016:1-13. doi: 10.1080/00140139.2016.1146343 [published Online First: 2016/01/26]

41. Russell BA, Summers MJ, Tranent PJ, et al. A randomised control trial of the cognitive effects of working in a seated as opposed to a standing position in office workers. *Ergonomics* 2016;59(6):737-44. doi: 10.1080/00140139.2015.1094579 [published Online First: 2015/09/29]

42. Shrestha N, Kukkonen-Harjula KT, Verbeek JH, et al. Workplace interventions for reducing sitting at work. *Cochrane Database of Systematic Reviews* 2018(6) doi:10.1002/14651858.CD010912.pub4

Résultats

La bonification de deux postes actifs en milieu de travail

L’un des grands enjeux dans ce domaine de recherche est de savoir quel(s) bureau(x) actif(s) permet de diminuer suffisamment et plus considérablement le temps assis pour prévenir les risques de santé associés au travail sédentaire. (Hamilton, Healy, Dunstan, Zderic, & Owen, 2008; Genevieve N. Healy, Matthews, Dunstan, Winkler, & Owen, 2011) Une méta-analyse basée sur 34 études et regroupant 3397 participants démontrait que c’est le bureau debout qui diminue le plus le temps assis au travail, concluant qu’il serait possible de diminuer le temps assis entre 84 et 116 minutes par jour avec ce type de bureau actif (N. Shrestha et al., 2018). Toutefois, une transition quotidienne de 120 à 240 minutes de temps sédentaire à des activités physiques à intensité légère est requise afin de diminuer les effets néfastes du temps sédentaire (Buckley et al., 2015). L’usage du seul bureau actif debout ne semble donc pas être une solution unique. La publication de notre article de revue (Dupont et al., 2019) nous révèle que chacun des trois bureaux actifs étudiés produit des effets différents, notamment sur l’humeur et la motivation. Aucune étude à notre connaissance n’avait décrit les effets de bonifier le milieu de travail d’un poste de travail debout et d’un poste à pédalier au bureau personnel d’un travailleur. Le travail de recherche au cœur de ce mémoire repose sur l’hypothèse selon laquelle la bonification de plus d’un poste actif (debout et avec pédalier) dans l’espace de travail des travailleurs favoriserait l’alternance d’utilisation entre le poste conventionnel assis, le poste debout et le poste à pédalier et augmenterait le temps actif pendant les tâches journalières.

Article #2

When office workers can choose their posture: The introduction of two active workstations for office workers to reduce sitting time and increase light physical activity

Article soumis à : Applied Ergonomics

Auteur : François Dupont, Ryan E.R. Reid, Marie-Eve Mathieu

When office workers can choose their posture: The introduction of two active workstations for office workers to reduce sitting time and increase light physical activity

Authors: François Dupont[1], Ryan E.R. Reid[1,2], Marie-Eve Mathieu[1,2]

Affiliations :

1 : École de kinésiologie et des sciences de l'activité physique, Université de Montréal, Montréal, Canada.

2 : Research center, Sainte-Justine University Hospital Center, Montréal, Canada.

Corresponding author:

Prof. Marie-Eve Mathieu, PhD

Université de Montréal, École de kinésiologie et des sciences de l'activité physique,

2100 boul. Edouard-Montpetit, Bureau 8202,

Montreal, QC, CAN, H3T 1J4,

514-343-6737

me.mathieu@umontreal.ca

Funding: Grant FIT24-health and productive work initiative by Social Sciences and Humanities Research and Canadian Institutes of Health Research (# 146019) and Research scholar from the Fonds de recherche Québec -Santé (#32983).

Keywords: Workplace; Interventions Occupational; Sedentary

Declarations of interest: none

Highlights:

- This study explored the feasibility of accumulating light physical activity and breaking up prolonged periods of sitting time when office workers are offered the choice of a standing and a cycling workstation.

- Participants accumulated on average 132 minutes of active workstation use per day which represents 46% of total time in their personal work area per day.

- As a result of the two active workstations, participants reduced their total desk-sitting time by half, and sat on average 30 minutes per sedentary bout.

Abstract

The purpose of this study was to explore the ability of accumulating light physical activity and breaking up prolonged periods of sitting time by introducing a standing and a cycling workstation in fifteen office workers. The total time spent on each type of workstation (i.e. seated, standing and cycling), comprised of the duration and frequency of use for each type of workstation, was assessed by video monitoring. From the total time at their desk, participants sat for 149.5 (71.4) min/day and used active workstations for 131.8 (73.0) min per day [t (14) = 0.819, p = 0.427]. When each active workstation was examined separately, participants spend 80.8 (61.38) minutes at the standing workstation and 57.7 (46.2) minutes at the cycling workstation [*t* (12) = 1.043, *p* = 0.318]. Also, participants changed working positions on average 12.0 (4.6) times per day. They sat 6.1 (3.1) times per day at their desk, which was similar to the frequency of active workstation use, 5.9 (2.5) times per day [*t* (14) = 0.309, *p* = 0.762]. Participants sat for short bouts of 27.6 (12.8) minutes at a time, which was not different from the bout duration of active workstation use, 22.5 (12.1) min/day, [t (14) = 1.320, p = 0.208]. In conclusion, the addition of standing and cycling workstations improved light physical activity and encouraged breaks in sitting time at work.

Introduction

Recently, there has been an increase in research surrounding the issue of ergonomic changes in office environments to reduce sedentary behaviours.(Fisher et al., 2016; Ng & Popkin, 2012; Neville Owen, Healy, et al., 2010) Sitting time at work contributes significantly to the accumulation of excessive sedentary time throughout the day.(Parry & Straker, 2013) Furthermore, there is a growing body of evidence which indicates that excessive sedentary behaviours and prolonged seating time have negative effects on cardiometabolic health and increases the risk of premature mortality.(Grace et al., 2019; Genevieve N. Healy et al., 2011; Rezende, Rey-López, Matsudo, & Luiz, 2014) As office workers spend 54% to 66% of their time sitting at workstations (Kazi, Duncan, Clemes, & Haslam, 2014; Ryan et al., 2011), the necessity of substituting sedentary behaviours with light intensity activities (i.e. standing, walking and cycling) in office-based workers to break up prolonged periods of sitting time appear obvious.(Ng & Popkin, 2012; Neville Owen, Sparling, Healy, Dunstan, & Matthews, 2010)

To help employees, employers and stake holders breakdown sedentariness, in 2015, an international group headed by Buckley published a consensus statement which recommends for workers to initially progress towards accumulating at least 2 hours of standing or light intensity activity (light walking) per day during working hours. Eventually, workers are invited to progress to a total accumulation of 4 hours per day in order to enhance active behaviours at work.(Buckley et al., 2015) Another approach by Owen et al. (2009) proposed breaking up prolonged sitting with 5 minutes of light physical activity every hour.(N. Owen et al., 2009) Considering these recommendations, the field of occupational health must begin to propose and evaluate new avenues to change sedentary behaviour at work and reach those guidelines.

Among strategies to reduce sedentary behaviour at work, active workstations, such as standing, treadmill or cycling, are considered to help workers accumulate some amount of light physical activity and promote breaks in sitting time.(Hutcheson et al., 2018; Neuhaus et al., 2014a; N. Shrestha et al., 2018) Despite initial results suggesting that active workstations can reduce sitting time at work and may improve physiologic health markers (Tudor-Locke et al., 2014), cognitive performance (Martin et al., 2015) and well-being (Sliter & Yuan, 2015), it is not clear how the simple addition of active workstations in the office environment will allow workers to meet the current recommendations.

Considering that certain job requirements may not be conducive to all types of active workstations, and that different types of active workstations offer various physiologic and cognitive benefits (Dupont et al., 2019), more than one type of active workstation may be required for optimal results in the work place. To date, no studies have commented on the feasibility of having more than one type of active workstation introduced in an office space to promote light physical activity and break up sitting time. The purpose of this study was to explore the ability of accumulating light physical activity and breaking up prolonged periods of sitting time when office workers are offered the choice of two different active workstations (i.e. standing and cycling).

Methodology

Population

Employees from five different organizations provided written informed consent to take part in this study. Three organizations were in the field of academia, one corporate organization and one non-profit organization, all with office workers. Inclusion criteria were: 1) workers 18–65 years old; 2) reported being an office worker sitting in their personal work area on average at least 6 hours per day and at least 4 consecutive days per week; 3) without chronic or acute musculoskeletal pain (e.g. back pain, tendinitis, shoulders, knee pain); and 4) not being currently pregnant.

Procedure

At baseline (week 0), body mass and body fat percentage were measured by bio-electric impedance (Tanita BF-350, Tanita corporation of America, Arlington Heights, Il) within 0.1 kilograms and 0.1%, respectively. Height was measured with a SECA stadiometer and waist circumference were measured to the nearest 0.1 cm. Body mass index (BMI) was calculated and categorized with World Health Organization adults charts.(World Health Organization, 2019) In addition, information concerning working days, working hours, sitting during work hours and moderate-to-vigorous intensity activities were collected using a form completed with a member of the research team.

At the beginning of week 1, active workstations were introduced by the research team. Two different workstations were set up: a portable cycling machine (DeskCycle2^{TM}, 3D Innovations, Colorado, United States) with resistance set at 22 watts (i.e. level 3, 60 revolutions per minute) and a standing desk with adjustable-height (ProPlus 36^{TM}, Varidesk, Texas, United States). These workstations were added in the office of each worker in addition to their existing seated workstation. No motivational tools were used or presents. On the standing workstation, a screen, keyboard and mouse were added to reproduce the sitting workstation arrangement. The portable cycling machine was installed under the seated workstation. Also, a video camera (Canon VIXIA HFR800 HD) was installed in the worker's immediate environment. The camera recorded the participants' lower segment (i.e. legs) for 24 hours a day and 7 days a week to determine the use workstations. The experiment involving the active workstations lasted two weeks (week 1 and 2).

Measurement

Video analysis was done chronologically. During the work day, the start and end times of each workstation used (sitting, standing or cycling) were noted. To be considered as a valid bout of use, the user must have spent at least 1.5 minutes continuously at the workstation. The outcomes of this video analysis were as follows: 1) total time spent at each type of workstation (seated, standing and cycling); 2) the duration of use for each type of workstation; and 3) the frequency of use for each type of workstation.

Data processing and statistical analysis

Questionnaire and video data were collected by two research trainees (FD, JF). Total time of use, duration of each use and frequency of use per day are the main outcomes. Outcomes were calculated on the first 8 of 10 workdays due to absences or days outside of the office. Data are presented as mean (standard deviation) unless otherwise specified. The average time of use of active workstations was used to identify different user groups: Gr- <2 hours/day of active workstation use; and Gr+ = ≥2 hours/day of active workstation use.(Buckley et al., 2015) Group differences were tested using ANOVA, and Cohen's d was calculated. The magnitudes of effect sizes were categorized as none (0 ≤ Cohen's d <0.20), small (0.20 ≤ Cohen's d <0.50), medium (0.50 ≤ Cohen's d <0.80), and large (Cohen's d ≥ 0.80). Paired t-tests were performed to test differences between conditions (i.e. Overall time in office, sitting workstation use, active workstation use, standing and cycling workstation use). The significance level was set at $p < 0.05$. All analyses were performed using SPSS Statistics software v25.0 (IBM Inc., Armonk, NY, USA).

Results

Fifteen office workers (93% female) with a mean age of 40.8 (11.5) years, a height of 165.8 (5.9) cm, a weight of 70.7 (17.9) kg, a body-fat percentage of 31.4 (7.1) % and a waist circumference of 84.7 (14.0) cm, had a BMI of 25.4 (4.8) kg/m^2 categorizing the sample between normal weight and overweight. Participants spent on average 162.5 (136.3) minutes per week practising moderate-to-vigorous intensity physical activity. This sample included individuals working in an office setting, with jobs that were defined by sitting [i.e. librarians (n=8), accounts (n=1), communications consultant (n=1), graphic designers (n=1), project managers (n=3)].

Before the introduction of active workstations, participants self-reported working 4.8 (0.4) days per week, spending on average 6.6 (0.8) hours a day at their personal work area and 32.0 (4.1) hours of sitting time per week. With the introduction of active workstations and video analysis, participants were seated at their desk for 4.6 (0.6) hours per day, which was significantly less than their self-reported time without active workstations [t (14) = 8.45, p = 0.001]. Of that total time spent at their personal work area, participants were sitting for 149.5 (71.4) min per day and used active workstations for 131.8 (73.0) min per day [t (14) = 0.819, p = 0.427]. When each active workstation was examined separately, participants spend 80.8 (61.38) minutes at the standing workstation and 57.7 (46.2) minutes at the cycling workstation [t (12) = 1.043, p = 0.318]. Also, participants changed working positions on average 12.0 (4.6) times per day. They sat 6.1 (3.1) times per day at their desk, which was similar to the frequency of active workstation use, 5.9 (2.5) times per day [*t* (14) = 0.309, *p* = 0.762]. When active workstations were examined separately, participants used standing workstations 3.2 (2.1) times and cycling workstations 2.7 (2.5) times per day [*t* (14) = 0.538, *p* = 0.599]. Considering all workstations, participants accumulated 27.7 (9.9) minutes for each change in position. On average, each sitting bout was short in duration, 27.6 (12.8) minutes, which was not different from the duration of bouts of active workstation use (22.5 (12.1) [*t* (14) = 1.320, *p* = 0.208]. Also, bouts of standing workstation use were, on average, 25.0 (16.2) minutes, and not different from bouts of cycling workstation use, 16.4 (13.3) [*t* (12) = 1.848, *p* = 0.089].

TABLE 1 ANTHROPOMETRIC AND WORK TIME BEHAVIOUR DIFFERENCES BETWEEN GROUPS

	Gr- **<2 hours/day of active workstation (N=8)**	**Gr+** **≥2 hours/day of active workstations (N=7)**		
	Mean (SD)	Mean (SD)	P-value	Cohen's *d*
Age (years)	37.3 (12.8)	44.0 (10.7)	.329	0.56
Anthropometry				
Height (cm)	165.7 (7.3)	166.1 (5.3)	.897	0.01
Weight (kg)	72.2 (21.6)	71.6 (15.1)	.849	0.03
BMI (kg/m^2)	25.1 (5.5)	25.8 (4.3)	.784	0.14
Total body fat (%)	29.9 (6.3)	33.9 (7.7)	.206	0.56
Waist circumference (cm)	82.0 (15.1)	87.8 (13.1)	.440	0.41
Work time behaviours				
Workdays per week (#)	4.8 (0.4)	4.9 (0.4)	.822	0.25
Time at work per workday (hours)	6.7 (1.1)	6.5 (0.4)	.661	0.24
Sitting time at work (hours/week)	32.3 (4.6)	31.6 (3.8)	.868	0.16
MVPA (minutes/week)	199.3§ (180.8)	125.7 (66.5)	.332	0.73

Values are mean and standard deviation (SD); Bold: significant difference between groups, p <0.05; BMI: body mass index; MVPA: Moderate and vigorous physical activities; § *N= (7)*

In total, 47% of participants used active workstations at least 2 hours per day (Gr+). On average, these workers accumulated 261% more minutes of active workstation use per day (*F* (1, 13) = 7.80, *p* = 0.015) and specifically, 284% more time using the standing workstation per day (*F* (1, 13) = 13.64, *p* = 0.003) compared to participants who did not spend at least 2 hours using active workstations per day (Gr-). These two groups displayed similar overall total time in their personal work area [Gr-: 275.7 (36.2) minutes; Gr+: 281.8 (33.6) minutes; *p* = 0.61], total number of bouts [Gr-: 12.5 (5.7); Gr: 11.5 (3.3); *p* = 0.70], and duration per bout [GR-: 26.0 (10.4) minutes; Gr: 29.3 (9.9) minutes; *p* = 0.99] (Table 2). Despite the magnitude of effect size for age (*p*=0.329; *D*=0.56), body fat % (*D*=0.56), waist circumference (*D*=0.41) and moderate-to-vigorous physical activity (*D*=0.73), no mean difference was found between participants of Gr+ and Gr- for anthropometric or work-time behaviour (Table 1).

TABLE 2 DIFFERENCES OF WORKSTATIONS USED BETWEEN GROUPS

	Gr- **<2 hours/day of active workstations** **(N=8)**	**Gr+** **≥2 hours/day of active workstations** **(N=7)**		
	Mean (SD)	Mean (SD)	P-values	Cohen's *d*
Total time (minutes/day)				
Overall	275.7 (36.2)	281.8 (33.6)	.610	0.17
Sitting workstation	201.9 (36.6)	88.3 (47.8)	**.00045**	2.67
Active workstation	75.4 (28.4)	197.6 (46.7)	**.00004**	3.16
Standing workstation	*43.7 (27.9)*	*124.4 (62.4)*	***.003***	1.67
Cycling workstation	*40.6 (36.6)*	*77.6 (51.3)*	*.160*	*0.83*
Frequency of use (#/day)				
Overall	12.5 (5.7)	11.5 (3.3)	.700	0.21
Sitting workstation	7.5 (3.3)	4.5 (2.3)	.060	1.06
Active workstation	5.0 (2.6)	6.9 (2.0)	.140	0.82
Standing workstation	*2.3 (2.0)*	*4.2 (1.9)*	*.100*	0.93
Cycling workstation	*2.6 (2.6)*	*2.7 (2.6)*	*.960*	*0.03*
Duration (minutes/use)				
Overall	26.0 (10.4)	29.3 (9.9)	.990	0.33
Sitting workstation	32.1 (13.0)	22.3 (11.2)	.090	0.81
Active workstation	14.9 (5.9)	31.3 (11.6)	**.015**	1.79
Standing workstation	*18.8 (15.5)*	*32.2 (14.8)*	*.160*	0.88
Cycling workstation	*11.4 (6.8)*	*22.3 (17.0)*	*.150*	0.84

Values are means and standard deviation (SD); Bold: significant difference between groups, p <.05.

Discussion

The objective of this study was to evaluate the influence of making two active workstations (i.e. standing and cycling) available to office workers in their workspace. Moreover, the feasibility of accumulating light physical activity and breaking up prolonged periods of sitting time when office workers are offered the choice of two different active workstations (i.e. standing and cycling) was assessed.

Light physical activity via active workstations

On average, participants accumulated 132 minutes of active workstation use per day, which represents 46% of the total time spent at their personal work area per day. Nearly two thirds of that time was spent using a standing workstation, compared to the other 44% of the time which was spent using a cycling workstation. Our findings agree with the literature, which reports a reduction in sitting time, in short-term studies, from 60 minutes to 120 minutes per day with the introduction of standing workstations (Hutcheson et al., 2018; N. Shrestha et al., 2018) and 23 min to 60 min per day using cycling workstations.(Neuhaus et al., 2014a; N. Shrestha et al., 2018) It appears that in our study, participants accumulated the same active time as other studies for each of the active workstations. This result supports that it is the addition of more than one type of active workstation which allowed for the accumulation of more than 2 hours of active time per day among participants and that no competition seems to occur between the active workstations. Nevertheless, even if participants did not statistically spend more time using the standing workstation (28% of working time at their personal work area) than the cycling workstation (20% of working time at their personal work area), it seems that the standing workstation is accountable for most of the light physical activity per day in the work environment.

Breaking up sitting time

On average, participants engaged in a total of 150 minutes of sitting time per day in their personal work area, which represented 54% of their usual seated time at their desk. For sitting time, participants sat at their desk for an average of about 28 minutes per bout. These results are not similar to those of Ryan et al. (2011) which, using a ball-bout and stand-sit bout, demonstrated that only 8% of their participants could achieve less than 55 minutes of continuous sitting time per day. Nevertheless, the hypotheses that offering workers the choice of several types of active workstations favouring light physical activity and breaking-up prolonged sitting time is supported by our results. Our study confirms that it is possible, using two active workstations, to achieve recommendations regarding maximum extended sitting time.(N. Owen et al., 2009) In the future, it will be important to further validate our findings with a greater sample size and long-term protocols.

Profiles between active workstation users

Participants who accumulated more than 2 hours of active workstation (Gr+) use per day throughout the first week of monitoring continued to accumulate at least 2 hours per day the following week. Likewise, no participant from the Gr- group moved to the GR + definition. These results may suggest that once active workstations are introduced into the workplace, a certain profile of workers may respond more positively to active workstations than others. Our results are similar to a study with a sample of 1098 participants, which identified 3 groups of standing workstation users over a period of 12 months: daily users, weekly users, and non-users. This finding was confirmed in our study, this time using two active workstations. Although not statistically different, large effect sizes were found that suggest that the participants of Gr+ tend to have more favourable active behaviours when they used the two active workstations in their personal work area compared to Gr- (i.e. They sat less often, used active workstations and standing workstations more often, for each duration of use they sat less time and bouts of standing and cycling workstations was longer). From a practical point of view, these interesting results (i.e. *cohen's d* between Gr- and Gr+) are likely to yield significant differences with a larger sample size.

There was no difference between groups for anthropometric or work time behaviour. However, it should be noted that, although not statistically significant, participants of Gr+ tended to be older (Δ6.7 years), to have a higher body fat percentage (Δ4%) and to engage in less weekly physical activity (Δ73 minutes/week). These results are important and lead to the hypothesis that the use of active workstations could reach a population that is naturally more sedentary. Some studies assessed age and sex differences among office workers and proposed that women sit for shorter periods of time and stand more often and longer than men.(Hallman et al., 2015; Toomingas, Forsman, Mathiassen, Heiden, & Nilsson, 2012) However, age did not seem to influence sedentary behaviours at work.(Hallman et al., 2015) Based on our findings, more studies are required to assess age, sex and body mass profiles in order to define the needs of sedentary workers. Also, understanding why certain active workstations are preferred over others is necessary to find the "right fit" (Leon Straker, 2019) to match workers' profiles in order to combat sedentary behaviour efficiently.

Strengths and Limitations

A major strength of this study was the use of video monitoring which gave a direct measurement of the outcomes.(Neville Owen & Zhu, 2017) In previous free-living studies, accelerometers and self-report questionnaires were primarily used, leading to data loss problems due to activity monitor dysfunction and relatively high attrition rates.(Chau et al., 2014; Chau et al., 2016; Renaud et al., 2018; Zhu et al., 2018) Also, this study was done in free-living environments instead of the laboratory and allowed us to explore the feasibility of the introduction of two active workstations where extraneous factors are inherently present. This design re-enforces the external validity of our results. Also, there was questionnaire information collected before the introduction of active workstations, which allowed for some comparison of sedentary behaviours before and after the introduction of the active workstations. The main limitation of this study was the relatively small sample size, which makes it impossible to conclude if our findings are generalizable to different types of work environments or by workers characteristics, such as sex and body weight. The second limitation was the lack of representativeness of men in our study (n=1). Those results our mainly bases on women workers' behaviours and cannot be generalizable for men workers.

Conclusion

This study explored the influence of the introduction of a standing and a cycling workstation into office workers personal work areas. Participants accumulated 132 minutes of active workstation use per day which represented nearly half of their total time spent in their personal work area per day. Furthermore, participants reduced their total daily sitting time, and each sitting-bout length was on average, less than half an hour. In total, 47% of participants used active workstations for at least 2 hours per day. This finding supports the hypothesis that a certain profile of workers may respond more positively to active workstations than others. Future studies should continue to consider the benefits of adding multiple types of active workstations in helping their employees attain health promoting behaviours which may lead to enhanced health benefits.

Acknowledgements

The authors wish to acknowledge the following individuals who contributed significant time and effort to the consensus development process and to the preparation of this manuscript: Jeremy Fabre and François Lecot. In addition, financing was obtained from Grant FIT24-health and productive work # 146019 initiative by Social Sciences and Humanities Research and Canadian Institutes of Health Research and Fonds de recherche Québec -Santé #32983.

References

1. Fisher A, Sawyer A, Wardle J, Smith L, McCourt O, Marmot A, et al. A review of occupational physical activity and sedentary behaviour correlates. Occupational Medicine. 2016;66(3):185-92.

2. Owen N, Healy GN, Matthews CE, Dunstan DW. Too Much Sitting: The Population-Health Science of Sedentary Behavior. Exercise and Sport Sciences Reviews. 2010;38(3):105-13.

3. Ng SW, Popkin BM. Time use and physical activity: a shift away from movement across the globe. Obesity Reviews. 2012;13(8):659-80.

4. Parry S, Straker L. The contribution of office work to sedentary behaviour associated risk. BMC public health. 2013;13(1):296.

5. Healy GN, Matthews CE, Dunstan DW, Winkler EAH, Owen N. Sedentary time and cardio-metabolic biomarkers in US adults: NHANES 2003–06. European Heart Journal. 2011;32(5):590-7.

6. Rezende LFMd, Rey-López JP, Matsudo VKR, Luiz OdC. Sedentary behavior and health outcomes among older adults: a systematic review. BMC public health. 2014;14(1):333.

7. Grace MS, Formosa MF, Bozaoglu K, Bergouignan A, Brozynska M, Carey AL, et al. Acute effects of active breaks during prolonged sitting on subcutaneous adipose tissue gene expression: an ancillary analysis of a randomised controlled trial. Scientific Reports. 2019;9(1):3847.

8. Ryan CG, Dall PM, Granat MH, Grant PM. Sitting patterns at work: objective measurement of adherence to current recommendations. Ergonomics. 2011;54(6):531-8.

9. Kazi A, Duncan M, Clemes S, Haslam C. A survey of sitting time among UK employees. Occupational Medicine. 2014;64(7):497-502.

10. Owen N, Sparling PB, Healy GN, Dunstan DW, Matthews CE. Sedentary behavior: emerging evidence for a new health risk. Mayo Clinic proceedings. 2010;85(12):1138-41.

11. Buckley JP, Hedge A, Yates T, Copeland RJ, Loosemore M, Hamer M, et al. The sedentary office: a growing case for change towards better health and productivity. Expert statement commissioned by Public Health England and the Active Working Community Interest Company. British Journal of Sports Medicine. 2015.

12. Owen N, Bauman A, Brown W. Too much sitting: a novel and important predictor of chronic disease risk? British Journal of Sports Medicine. 2009;43(2):81.

13. Hutcheson AK, Piazza AJ, Knowlden AP. Work Site-Based Environmental Interventions to Reduce Sedentary Behavior: A Systematic Review. American journal of health promotion : AJHP. 2018;32(1):32-47.

14. Shrestha N, Kukkonen-Harjula KT, Verbeek JH, Ijaz S, Hermans V, Pedisic Z. Workplace interventions for reducing sitting at work. Cochrane Database of Systematic Reviews. 2018(6).

15. Neuhaus M, Eakin EG, Straker L, Owen N, Dunstan DW, Reid N, et al. Reducing occupational sedentary time: a systematic review and meta-analysis of evidence on activity-permissive workstations. Obesity reviews : an official journal of the International Association for the Study of Obesity. 2014;15(10):822-38.

16. Tudor-Locke C, Schuna JM, Frensham LJ, Proenca M. Changing the way we work: elevating energy expenditure with workstation alternatives. Int J Obes. 2014;38(6):755-65.

17. Martin A, Fitzsimons C, Jepson R, Saunders DH, van der Ploeg HP, Teixeira PJ, et al. Interventions with potential to reduce sedentary time in adults: systematic review and meta-analysis. British Journal of Sports Medicine. 2015.

18. Sliter M, Yuan Z. Workout at work: Laboratory test of psychological and performance outcomes of active workstations. Journal of occupational health psychology. 2015;20(2):259-71.

19. Dupont F, Léger P-M, Begon M, Lecot F, Sénécal S, Labonté-Lemoyne E, et al. Health and productivity at work: which active workstation for which benefits: a systematic review. Occupational and environmental medicine. 2019;76(5):281.

20. World Health Organization. Obesity and overweight 2019 [Available from: https://www.who.int/en/news-room/fact-sheets/detail/obesity-and-overweight.

21. Hallman D, Mathiassen S, Gupta N, Korshøj M, Holtermann A. Differences between work and leisure in temporal patterns of objectively measured physical activity among blue-collar workers. BMC public health. 2015;15.

22. Toomingas A, Forsman M, Mathiassen S, Heiden M, Nilsson T. Variation between seated and standing/walking postures among male and female call centre operators. BMC public health. 2012;12:154.

23. Owen N, Zhu W. Sedentary behavior and health : concepts, assessments, and interventions: Champaign : Human Kinetics; 2017.

24. Renaud LR, Huysmans MA, van der Ploeg HP, Speklé EM, van der Beek AJ. Long-Term Access to Sit-Stand Workstations in a Large Office Population: User Profiles Reveal Differences in Sitting Time and Perceptions. International journal of environmental research and public health. 2018;15(9):2019.

25. Zhu W, Gutierrez M, Toledo MJ, Mullane S, Stella AP, Diemar R, et al. Long-term effects of sit-stand workstations on workplace sitting: A natural experiment. Journal of Science and Medicine in Sport. 2018;21(8):811-6.

26. Chau JY, Daley M, Dunn S, Srinivasan A, Do A, Bauman AE, et al. The effectiveness of sit-stand workstations for changing office workers' sitting time: results from the Stand@Work randomized controlled trial pilot. The international journal of behavioral nutrition and physical activity. 2014;11:127.

27. Chau JY, Sukala W, Fedel K, Do A, Engelen L, Kingham M, et al. More standing and just as productive: Effects of a sit-stand desk intervention on call center workers' sitting, standing, and productivity at work in the Opt to Stand pilot study. Preventive Medicine Reports. 2016;3:68-74.

Discussion

L’augmentation du temps sédentaire au travail dans les pays occidentaux et non occidentaux est un enjeu de santé publique (Ng & Popkin, 2012). De plus, la littérature scientifique nous indique que la pratique de 150 minutes par semaine d’activité physique d’intensité moyenne à élevée ne suffit pas à renverser les conséquences (Ex. diabète, hypertension, douleurs musculo-squelettiques) d’un surplus de temps sédentaire (Benatti & Ried-Larsen, 2015; Hamilton, Hamilton, & Zderic, 2007; HOWARD et al., 2013). Pour les chercheurs en médecine de la santé au travail et le domaine de l’ergonomie, les bureaux actifs font partie des nouvelles façons de penser l’ergonomie de travail (Holtermann et al., 2019). Cette nouvelle approche est axée sur le juste apport quotidien d’activité physique légère sur les heures de travail (Leon Straker, 2019). Les bureaux actifs tels que les bureaux debout, avec pédalier ou avec tapis roulant pourraient offrir cette opportunité de briser les longues périodes de temps assises et d’ajouter du temps actif sur les heures de travail (MacEwen et al., 2015; Neuhaus et al., 2014b).

La première recherche sur les bureaux actifs date maintenant d’une trentaine d’années (Edelson & Danoffz, 1989). Depuis, l’état des connaissances est maintenant assez étoffé pour permettre d’en dresser les bases scientifiques, notamment sur les effets physiologiques (MacEwen et al., 2015; Podrekar, Kozinc, & Šarabon, 2018; Tine Torbeyns et al., 2014; Tudor-Locke et al., 2014) et biomécaniques (la posture, l’activité musculaire et le contrôle moteur) lors de l’utilisation des différents bureaux actifs versus la posture assise (Agarwal, Steinmaus, & Harris-Adamson, 2018; Botter et al., 2016; Fedorowich et al., 2015; Lin, Barbir, & Dennerlein, 2017; Yoon et al., 2019). Les postes actifs sont de plus en plus reconnus comme permettant des améliorations cognitives telles que la mémorisation, l’attention et la résolution de problème, des améliorations sur l’état d’éveil, l’ennui et la motivation au travail (Bantoft et al., 2016; Huang et al., 2019; Ojo et al., 2018; Sliter & Yuan, 2015). Notre article de revue présenté dans la recension des écrits est venu pour la première fois recenser les études comparant non pas un bureau actif au poste sédentaire, mais plusieurs bureaux actifs entre eux pour outiller la prise de décision quand un seul bureau est introduit. Il propose que les effets entre les différents types de bureaux actifs ne soient pas identiques et que le choix du (des) bureau (x) actif(s) par les employeurs et les employés doivent être spécifiques à leurs besoins (Dupont et al., 2019).

Discussion des résultats

Considérant que les exigences de travail diffèrent d'un emploi à l'autre et que différents types de postes de travail actifs offrent divers avantages physiologiques, biomécaniques et cognitifs (Dupont et al., 2019), plusieurs types de postes de travail actifs peuvent être nécessaires afin d'optimiser la lutte à la sédentarité dans les milieux de travail. Le but de l'étude présenté dans la section résultat de ce mémoire était l'observation 1) de la capacité d'accumuler de l'activité physique à intensité légère à l'aide de deux bureaux actifs (poste debout et poste à pédalier) ; 2) de la capacité de fragmenter les longues périodes de temps en position assise pour les employés à l'aide des postes actifs et 3) des différences de profil entre les participants respectant ou non le minium de temps d'utilisation des postes actifs recommandé.

Le recrutement

Il convient de souligner d'emblée que le recrutement dans les milieux de travail a été facile. Les employeurs et les employés ont démontré un vif intérêt à expérimenter pour une durée de deux semaines l'ajout de bureaux actifs dans leur environnent de travail. Ce sont très majoritairement les femmes qui ont accepté l'invitation de participer à l'intervention (14 femmes sur 15 participants), et ce malgré une présence équivalente de collègues masculins dans leur milieu de travail. Ce résultat est surprenant considérant des proportions homme/femme plus paritaires observées dans d'autres études avec des interventions faites dans les milieux de travail (Hadgraft et al., 2016; G. N. Healy et al., 2016; Renaud et al., 2018). Ceci pourrait dénoter un intérêt particulier des femmes pour ce type d'intervention qui contre la sédentarité au travail. En effet, deux études qui ont évalué les différents comportements sédentaires de travailleurs de bureaux suggèrent que les femmes passeraient moins de temps assises que les hommes à leur bureau (Hallman et al., 2015). De plus, elles seraient plus propices que les hommes à passer du temps debout dans la journée de travail (Hallman et al., 2015; Toomingas et al., 2012).

Les grandes enquêtes populationnelles tendent toutefois à démontrer que les femmes accumulent en absolu plus de temps sédentaire que les hommes dans la semaine (World Health Organization, 2008), faisant d'elle une population de choix à la lutte aux comportements sédentaires. En 2013, une étude avec un échantillon de plus de 600 travailleurs de bureau observait des taux plus élevés de troubles musculo-squelettiques pour les femmes (10 % plus élevé pour les travailleuses que pour les hommes). (Madeleine, Vangsgaard, Hviid Andersen, Ge, & Arendt-Nielsen, 2013) Aussi, on remarque que les femmes ont des arrêts de travail plus longs suite à des accidents de travail (Ex. trouble musculo-squelettique) (Lederer, Rivard, & Mechakra-Tahiri, 2012; Macpherson et al., 2019). Finalement, malgré différents types d'aménagement de bureaux (cubicule, bureau fermé ou espace commun) on rapporte que les femmes seraient plus sédentaires au travail que leurs collègues masculins et présentaient un taux de stress au travail plus élevé que les hommes. (Lindberg et al., 2018) Aux États-Unis, 50 % des employées sont des femmes. Ces mêmes femmes occupent de plus en plus des métiers hautement stressants et sédentaires (Palumbo et al., 2017). Dans ce contexte, l'intérêt démontré par les femmes comparativement aux hommes à participer à notre étude est congruent. Il suggère que les bureaux actifs pourraient être un outil attrayant à la lutte aux comportements sédentaires au travail pour la travailleuse de bureau. Dans de futures études, il sera donc important de connaitre les spécificités et préférences entre les genres afin de répondre adéquatement aux besoins particuliers des femmes et des hommes dans les milieux de travail.

Temps sédentaire

Durant les deux semaines d'intervention, les travailleurs ont cumulé en moyenne 149 minutes (2,5 heures) de temps assis par jour dans leur bureau. Ceci représente en moyenne 53 % du temps passé dans leur bureau (149/278 minutes) et 38 % du temps passé au travail (149/396 minutes). Pour ce faire, les travailleurs ont changé de poste de travail en moyenne 12 fois par jour. Ils s'assoient à leur poste assis conventionnel en moyenne 6 fois par jour et cumulent en moyenne 28 minutes de temps assis à chacune des périodes. Ainsi, dans notre étude la simple introduction de 2 bureaux actifs amène les employés à respecter la recommandation d'avoir des périodes de temps assis d'au maximum 55 minutes et ce malgré l'absence de toute mesure motivationnelle (ex. formation, service de consultation ou brochure motivationnelle). (N. Owen et al., 2009; Ryan et al., 2011) Il serait donc possible de briser adéquatement le temps assis à l'aide de deux postes actifs, du moins à court terme. De nombreuses études démontrent que de fragmenter le temps assis dans une journée de travail apporte de nombreux bienfaits sur la santé métabolique, la santé cardiaque et diminuerait les risques de mortalité. (Benatti & Ried-Larsen, 2015; Genevieve N. Healy et al., 2008; Mackie et al., 2019; Peddie et al., 2013) Dans cette optique, de futures études qui mesurent les effets sur la santé de la fragmentation du temps assis et ce, à l'aide de 2 postes actifs seront nécessaires afin de valider nos résultats.

Temps actif

Il est généralement admis que la réduction de temps assis au travail se transfère en temps actif (Maedeh Mansoubi, Pearson, Biddle, & Clemes, 2014; N. Shrestha et al., 2018). Dans notre étude, les travailleurs ont eu en moyenne une utilisation quotidienne des postes actifs de 132 minutes. Cette moyenne journalière se décline en 81 minutes pour le poste debout et 58 minutes pour le poste à pédalier. Donc, nos résultats suggèrent que l'ajout de deux postes actifs à même un aménagement existant augmente le temps actif au quotidien et ce, au-delà de l'ajout d'un seul poste actif. En effet, les études antérieures sur les postes actifs recensent des temps de 80 à 120 minutes pour les postes debout et de 23 à 60 minutes pour le poste à pédalier (Hutcheson et al., 2018; Neuhaus et al., 2014b; N. Shrestha et al., 2018). Ainsi, on constate un effet additif et non une compétition entre les postes actifs. Il serait possible d'accumuler en moyenne plus de 120 minutes d'activité physique à intensité légère et atteindre les recommandations proposées par Buckley et al. (2015). Nos résultats suggèrent aussi que certaines barrières telles que la peur d'une diminution de la productivité (Hadgraft et al., 2016) ou le jugement des pairs (Qin, Sun, Liu, & Leyva, 2019) identifiés par d'autres groupes n'ont pas affecté négativement l'utilisation des deux postes actifs. En contrepartie, une étude de 2016 concluait que le transfert de temps assis en temps actif à l'aide du poste debout se traduisait en une diminution du temps actif en dehors des heures de travail(M. Mansoubi, Pearson, Biddle, & Clemes, 2016). Cette mise en garde doit être prise au sérieux et mérite d'être étudiée tant dans des protocoles similaires à celui-ci, soit à court terme, que dans des conditions où l'usage des bureaux actifs se fait sur plusieurs mois.

Comportement d'utilisation

Les quinze travailleurs ont utilisé les postes actifs plusieurs fois par jour, soit en moyenne trois fois par jour pour chacun des deux postes actifs. Ils accumulent ainsi une moyenne de 25 minutes pour le bureau debout et 16 minutes pour le bureau avec pédalier à chacune des utilisations. Cette utilisation fréquente, mais aussi de courte durée (en moyenne 16 minutes) des postes actifs rapportée dans nos résultats est pertinente dans le contexte entourant la sécurité d'utilisation des bureaux actifs. Par exemple, les dangers que représente une utilisation quotidienne et prolongée des bureaux actifs sur les douleurs musculo-squelettiques sont récemment questionnés (Baker et al., 2019; Coenen et al., 2018; Kermit G. Davis & Kotowski, 2015). Toutefois, avec des utilisations en deçà de 30 minutes, la fragmentation des périodes de temps assis avec l'utilisation de bureaux actifs permet la prévention de douleur musculaire et de pathologie chronique telle que les tendinopathies et les maladies inflammatoires, notamment au niveau lombaire (Agarwal et al., 2018; Karakolis & Callaghan, 2014). Basées sur nos résultats (utilisation fréquente et de courte durée), de prochaines études devront s'adresser à l'impact musculo-squelettique des utilisations fréquentes de moins de 30 minutes des bureaux actifs et ce, à court et à long terme.

Différence d'utilisation entre les sous-groupes de travailleurs

On remarque que deux types d'utilisateurs semblent émerger de l'échantillon sur la base des recommandations actuelles (> deux heures/jour) : un groupe de huit travailleurs qui utilisent les postes actifs moins que 2 heures par jour (Gr -) et un groupe de sept travailleurs qui utilisent les postes actifs pour deux heures ou plus par jour (Gr+). Les travailleurs du groupe Gr+ ont eu tendance à utiliser presque deux fois de plus le poste debout (1,8 fois) pendant la journée versus les travailleurs de Gr -. Ils ont aussi accumulé en moyenne 13 minutes de plus sur le poste debout et 10 minutes de plus sur le poste à pédalier que le groupe GR- et ce, à chacune de leur utilisation. Ce faisant, on remarque une différence significative de 122 minutes de temps assis entre les travailleurs de Gr+ et de Gr -. De plus, malgré l'absence de différences statistiques, les travailleurs de Gr+ étaient en moyenne plus âgés (+7 ans), avaient un pourcentage de masse adipeuse plus élevé (Δ7 points de pourcentage) et avaient un tour de taille plus élevé (Δ5 cm). Ces résultats évoquent la possibilité qu'un type de travailleurs soit plus réceptif à l'utilisation des postes actifs et que des interventions spécifiques méritent d'être offertes pour outiller les travailleurs. De plus, les travailleurs qui ont répondu le plus favorablement à l'introduction des deux postes actifs (Gr+) sont également ceux qui présentaient un profil moins favorable à la santé avec un pourcentage de masse adipeuse plus élevé (34 %) et un tour de taille au seuil inférieur de l'obésité abdominale (88 cm) que leur homologue (Gr -) (U.S. Department of Health & Human Services, 2010). Ces résultats peuvent être contre-intuitifs, car les travailleurs ayant un profil d'obésité sont plus propices à la fatigue que procure l'activité physique même légère, faisant de cette réalité une barrière à l'implantation des bureaux actifs dans leur ergonomie de travail (Josaphat et al., 2019). Une étude de Thorp et al. (2016) propose qu'un changement du poste assis au poste debout toutes les 30 minutes diminue pour les travailleurs obèses les douleurs musculo-squelettiques et les inconforts musculaires. De plus, sachant que l'activité musculaire diffère selon le type de bureau actif, une utilisation en alternance entre les deux types de postes actifs permettrait pour les travailleurs aux prises avec un surplus de poids ou de l'obésité de diminuer leur temps sédentaire et d'accumuler du temps actif sans toutefois se fatiguer de manière excessive. Il est avancé que l'ajout de postes actifs pourrait être un outil au contrôle pondéral (Betts et al., 2019). De plus, pour une durée et des intensités d'utilisation relativement faible, les travailleurs en condition d'obésité bénéficient en absolue d'une plus grande dépense énergétique et d'une diminution plus marquée la pression systolique que les autres travailleurs (Josaphat et al., 2019). Sachant que les travailleurs ayant un profil d'obésité cumulent plus de temps sédentaire que les autres travailleurs (Clemes et al., 2015), la validation de nos résultats et la compréhension des perceptions de la bonification de deux postes actifs dans l'espace de travail des travailleurs ayant un profil d'embonpoint et d'obésité sont une avenue intéressante à explorer.

Avenues de recherche et limites

Le premier objectif du projet « *Travail sédentaire et bureaux actifs* » se concentrait principalement sur la faisabilité d'introduire deux postes de bureaux actifs dans les milieux de travail afin d'accumuler au travail de l'activité physique à intensité légère. La prise de la mesure du temps actif et assis fut réalisée à l'aide d'enregistrement vidéo et ce, sur une la durée de deux semaines, moment où les bureaux actifs étaient présents. Ce faisant, l'enregistrement vidéo nous a permis d'assurer une qualité de mesure notamment sur le temps d'utilisation du poste à pédalier pour lesquelles l'utilisation des accéléromètres n'a pas été encore validée (Barreira, Zderic, Schuna, Hamilton, & Tudor-Locke, 2015; Herman Hansen et al., 2014). Toutefois, la prise d'image étant restreinte au bureau personnel du travailleur, elle ne nous a pas permis d'avoir un portrait global des changements de comportement sédentaire au travail. En effet, l'ajout d'accéléromètres en plus de l'analyse vidéo nous aurait permis d'avoir une vue globale des comportements actifs et sédentaires pour les travailleurs au travail et à la maison. Certains auteurs mettent en doute l'efficacité des bureaux actifs à diminuer le temps sédentaire (M. Mansoubi et al., 2016). Ils affirment que le temps actif accumulé à l'aide de bureaux actifs pourrait être compensé par une réduction des activités physiques en dehors des heures de travail. Dans les futures études, il sera donc important de mesurer l'ensemble des comportements sédentaires à court et à long terme afin de déterminer s'il y a un changement réel des comportements sédentaires chez les travailleurs de bureaux.

Le deuxième objectif du projet portait sur à la capacité de briser les longues périodes de temps en position assise pour les employés à l'aide des postes actifs. Nos résultats supportent l'idée qu'il est effectivement possible de fragmenter de manière importante les périodes assises au cours de la journée de travail. Comme décrit dans la recension des écrits, plusieurs bénéfices liés à la santé sont associés au fait de fragmenter les longues périodes de temps assis. Une deuxième étape à cette étude serait de mesurer les effets sur la santé et sur la productivité de ces intermittences entre le poste assis et les postes actifs. Bien qu'à ce jour, quelques études supportent l'idée que de diminuer les longues périodes de temps assis augmente la productivité et le bien-être au travail (Abdin, Welch, Byron-Daniel, & Meyrick, 2018; Nam et al., 2017; Puig-Ribera et al., 2015), aucune évidence scientifique ne nous permet de savoir après combien de temps, nous devrions changer de poste de travail (ex : bureau assis à bureau actif) afin de diminuer les impacts de la sédentarité sur la santé tout en restant efficace dans les tâches du travail. Également, nous ne sommes pas en mesure de déterminer si un changement fréquent de posture peut avoir un effet positif sur la charge mentale du travail de bureau. Nos résultats révèlent qu'en moyenne les travailleurs changeaient 12 fois par jour de postes de travail et pour une durée moyenne de 28 minutes tout poste de travail confondu. Basé sur ces résultats, un approfondissement des connaissances sur l'impact de ces changements fréquents de postes de travail est nécessaire afin de mettre en évidence les meilleures pratiques d'utilisation des postes actifs en milieu de travail.

Le projet avait comme troisième objectif d'observer les différences entre les travailleurs répondant ou non à l'introduction de deux postes actifs. La petite taille de notre échantillon (n=15) ne nous permet pas de conclure sur l'ensemble des différences mesurées entre les participants de Gr+ (N=7) et Gr- (N=8). Toutefois, malgré des différences non significatives, nous avons pu dénoter entre les travailleurs du Gr+ et ceux du Gr- des tailles d'effets allant de moyenne à larges. Des tailles d'effet catégorisées larges sont ressorties des analyses pour : 1) la mesure du temps d'utilisation quotidien de postes à pédalier ; 2) sur les mesures de la fréquence d'utilisation du poste assis, la fréquence d'utilisation des postes actifs et la fréquence d'utilisation du poste debout et ; 3) sur le temps d'utilisation du poste debout/fréquence d'utilisation. Il est probable qu'un échantillon plus grand permettra la mise en évidence de ces différences entre les groupes. Ces informations sont importantes, à savoir si certains travailleurs ont des préférences vis-à-vis l'utilisation des deux postes actifs. Finalement, un échantillon plus grand avec une parité entre les sexes permettrait d'avoir des résultats plus représentatifs des travailleurs de bureaux en général, de leurs préférences, de leurs besoins et de leur capacité à diminuer leur temps sédentaire au travail.

Le projet « *Travail sédentaire et bureaux actifs* » s'adressait exclusivement aux travailleurs de bureau. Une reproduction de notre protocole serait également pertinente dans d'autres milieux. Par exemple, on retrouve dans les écoles primaires et secondaires des temps assis similaires à ceux répertoriés pour les travailleurs de bureau. Une autre similitude avec les travailleurs de bureau est que l'accumulation de temps assis serait plus élevée pour les filles, les élèves avec obésités et les élèves plus âgés (da Costa, da Silva, George, & de Assis, 2017; van Stralen et al., 2014). Quelques résultats quant à l'aide que peuvent apporter les bureaux actifs en classe ressortent. Parmi ceux-ci, on rapporte une diminution du temps sédentaire de 60 minutes par jour avec le poste debout pour les élèves du primaire (Hinckson et al., 2015). Aussi, des améliorations de l'ordre de 7 % à 14 % sur les tâches de mémorisation et des tâches cognitives exécutives (ex. temps de réaction pour identification d'objet) pour des élèves du secondaire avec l'utilisation du poste debout (Mehta, Shortz, & Benden, 2015) et des bienfaits musculo-squelettiques pour les adolescents avec le poste debout et le poste à pédalier (Ee et al., 2018; T. Torbeyns et al., 2017). Il est connu que l'aménagement des écoles a un impact sur les comportements sédentaires et sur le bien-être des élèves (Brittin et al., 2017). Basée sur nos résultats, la bonification des milieux scolaires par l'ajout de plusieurs types de bureaux actifs pourrait faire partie d'un ensemble d'outils qui comprend aussi les corridors actifs et les pauses actives afin de favoriser la pratique d'activité physique et ces bienfaits dans les écoles. Finalement, considérant le nombre grandissant d'élèves ayant des troubles de l'apprentissage et d'hyperactivité dans les écoles, la mise en place des bureaux actifs qui permettent aux enfants diagnostiqués de bouger tout en travaillant pourrait être un outil adapté à cette clientèle (Aminian, Hinckson, & Stewart, 2015; Sarver, Rapport, Kofler, Raiker, & Friedman, 2015).

Contribution personnelle

La première année de maitrise fut consacrée à l'écriture d'une revue de littérature permettant d'approfondir mes connaissances sur les concepts entourant les bureaux actifs. Cette revue approfondie m'a permis de mettre en lumière les différences probables entre les différents types de bureaux actifs. Ce travail, réalisé avec la collaboration des coauteurs et dans le contexte du projet FIT24 (IRSC/CRSH), a permis la publication de l'article de revue (Dupont et al., 2019) basé sur les directives de PRISMA. Par la suite, le projet « *Travail sédentaire et bureaux actifs* » élaboré avec l'aide de ma directrice de recherche m'a permis de me familiariser avec l'écriture d'une demande éthique et les différentes étapes de la mise en place d'un projet de recherche (planification et les achats des différents outils de mesure, recrutement et collecte de données auprès d'employés des différentes compagnies et organisations). Par la suite, la transformation des données brutes, les analyses statistiques et l'interprétation des données m'ont permis d'apprendre sur le travail analytique propre de la recherche. Finalement, l'écriture du deuxième article présenté en résultat dans ce mémoire avec la collaboration de Dr Ryan ER Reid et de ma directrice de recherche m'a donné un aperçu global de la complétion de projets de recherche.

Conclusion

Le style de vie menant à la sédentarité est de plus en plus présent dans nos sociétés dites modernes. Parmi les outils pouvant contribuer à la lutte à la sédentarité, la réorganisation de l'ergonomie du travail via l'ajout de bureaux actifs représente un changement de paradigme important dans les aménagements de travail. Une meilleure compréhension des différences entre les types de bureaux est nécessaire afin d'arrimer les besoins des travailleurs et les différents bénéfices que pourraient leur apporter les bureaux actifs. De plus, un retour de l'apport de l'activité physique légère à l'intérieur de nos tâches de travail est de plus en plus supporté par la recherche scientifique. Pour ce faire, une pluralité des outils tels que les différents postes actifs sont nécessaire dans l'optique où chacun des travailleurs et travailleuses ont des besoins, des contraintes et des préférences qui lui leur sont propres. Pour conclure, ce projet de mémoire a eu pour but d'inciter l'approfondissent et la réflexion des stratégies potentielles au mieux-être et la santé dans les milieux de travail. Espérant qu'il saura alimenter de prochaines questions de recherche auprès des spécialistes de la santé, de l'activité physique, de l'ergonomie et de la sécurité au travail.

Bibliographie

Abdin, S., Welch, R. K., Byron-Daniel, J., & Meyrick, J. (2018). The effectiveness of physical activity interventions in improving well-being across office-based workplace settings: a systematic review. *Public Health, 160*, 70-76. doi:https://doi.org/10.1016/j.puhe.2018.03.029

Agarwal, S., Steinmaus, C., & Harris-Adamson, C. (2018). Sit-stand workstations and impact on low back discomfort: a systematic review and meta-analysis. *Ergonomics, 61*(4), 538-552. doi:10.1080/00140139.2017.1402960

Agence de la santé publique du Canada. (2016). État de santé des Canadiens 2016. Retrieved from http://canadiensensante.gc.ca/publications/department-ministere/state-public-health-status-2016-etat-sante-publique-statut/alt/pdf-fra.pdf

Ainsworth, B. E., Haskell, W. L., Whitt, M. C., Irwin, M. L., Swartz, A. M., Strath, S. J., . . . Leon, A. S. (2000). Compendium of Physical Activities: an update of activity codes and MET intensities. *Medicine & Science in Sports & Exercise, 32*(9), S498-S516. Retrieved from https://journals.lww.com/acsm-msse/Fulltext/2000/09001/Compendium_of_Physical_Activities__an_update_of.9.aspx

Altenburg, T. M., Rotteveel, J., Serné, E. H., & Chinapaw, M. J. M. (2019). Standing is not enough: A randomized crossover study on the acute cardiometabolic effects of variations in sitting in healthy young men. *Journal of Science and Medicine in Sport*. doi:https://doi.org/10.1016/j.jsams.2018.12.016

Aminian, S., Hinckson, E. A., & Stewart, T. (2015). Modifying the classroom environment to increase standing and reduce sitting. *Building Research & Information, 43*(5), 631-645. doi:10.1080/09613218.2015.1058093

Baker, R., Coenen, P., Howie, E., Williamson, A., & Straker, L. (2018). The Short Term Musculoskeletal and Cognitive Effects of Prolonged Sitting During Office Computer Work. *International journal of environmental research and public health, 15*(8), 1678. doi:10.3390/ijerph15081678

Baker, R., Coenen, P., Howie, E., Williamson, A., & Straker, L. (2019). The musculoskeletal and cognitive effects of under-desk cycling compared to sitting for office workers. *Applied Ergonomics, 79*, 76-85. doi:https://doi.org/10.1016/j.apergo.2019.04.011

Bantoft, C., Summers, M. J., Tranent, P. J., Palmer, M. A., Cooley, P. D., & Pedersen, S. J. (2016). Effect of Standing or Walking at a Workstation on Cognitive Function: A Randomized Counterbalanced Trial. *Hum Factors, 58*(1), 140-149. doi:10.1177/0018720815605446

Barreira, T. V., Zderic, T. W., Schuna, J. M., Hamilton, M. T., & Tudor-Locke, C. (2015). Free-living activity counts-derived breaks in sedentary time: Are they real transitions from sitting to standing? *Gait & Posture, 42*(1), 70-72. doi:https://doi.org/10.1016/j.gaitpost.2015.04.008

Benatti, F. B., & Ried-Larsen, M. (2015). The Effects of Breaking up Prolonged Sitting Time: A Review of Experimental Studies. *Medicine & Science in Sports & Exercise, 47*(10), 2053-2061. doi:10.1249/mss.0000000000000654

Betts, J. A., Smith, H. A., Johnson-Bonson, D. A., Ellis, T. L., Dagnall, J., Hengist, A., . . . Afman, G. H. (2019). The Energy Cost of Sitting versus Standing Naturally in Man. *Medicine & Science in Sports & Exercise, 51*(4), 726-733. doi:10.1249/mss.0000000000001841

Biddle, S. J. H., Edwardson, C. L., Wilmot, E. G., Yates, T., Gorely, T., Bodicoat, D. H., . . . Davies, M. J. (2015). A Randomised Controlled Trial to Reduce Sedentary Time in Young Adults at Risk of Type 2 Diabetes Mellitus: Project STAND (Sedentary Time ANd Diabetes). *PLOS ONE, 10*(12), e0143398. doi:10.1371/journal.pone.0143398

Blair, S. N., Davey Smith, G., Lee, I. M., Fox, K., Hillsdon, M., McKeown, R. E., . . . Marmot, M. (2010). A Tribute to Professor Jeremiah Morris: The Man Who Invented the Field of Physical Activity Epidemiology. *Annals of Epidemiology, 20*(9), 651-660. doi:https://doi.org/10.1016/j.annepidem.2010.06.001

Botter, J., Ellegast, R. P., Burford, E. M., Weber, B., Konemann, R., & Commissaris, D. A. (2016). Comparison of the postural and physiological effects of two dynamic workstations to conventional sitting and standing workstations. *Ergonomics, 59*(3), 449-463. doi:10.1080/00140139.2015.1080861

Brittin, J., Frerichs, L., Sirard, J. R., Wells, N. M., Myers, B. M., Garcia, J., . . . Huang, T. (2017). Impacts of active school design on school-time sedentary behavior and physical activity: A pilot natural experiment. *PLOS ONE, 12*(12), e0189236-e0189236. doi:10.1371/journal.pone.0189236

Buckley, J. P., Hedge, A., Yates, T., Copeland, R. J., Loosemore, M., Hamer, M., . . . Dunstan, D. W. (2015). The sedentary office: a growing case for change towards better health and productivity. Expert statement commissioned by Public Health England and the Active Working Community Interest Company. *British Journal of Sports Medicine*. Retrieved from http://bjsm.bmj.com/content/early/2015/04/23/bjsports-2015-094618.abstract

Carnethon, M., Whitsel, L. P., Franklin, B. A., Kris-Etherton, P., Milani, R., Pratt, C. A., & Wagner, G. R. (2009). Worksite Wellness Programs for Cardiovascular Disease Prevention. *Circulation, 120*(17), 1725. Retrieved from http://circ.ahajournals.org/content/120/17/1725.abstract

Carr, L. J., Karvinen, K., Peavler, M., Smith, R., & Cangelosi, K. (2013). Multicomponent intervention to reduce daily sedentary time: a randomised controlled trial. *BMJ Open, 3*(10), e003261. doi:10.1136/bmjopen-2013-003261

Centers for Disease Contril and Prevention. (2017). Worksite Physical Activity. Retrieved from https://www.cdc.gov/physicalactivity/worksite-pa/index.htm

Champion, R. B., Smith, L. R., Smith, J., Hirlav, B., Maylor, B. D., White, S. L., & Bailey, D. P. (2018). Reducing prolonged sedentary time using a treadmill desk acutely improves cardiometabolic risk markers in male and female adults. *Journal of Sports Sciences, 36*(21), 2484-2491. doi:10.1080/02640414.2018.1464744

Chau, J. Y., Daley, M., Dunn, S., Srinivasan, A., Do, A., Bauman, A. E., & van der Ploeg, H. P. (2014). The effectiveness of sit-stand workstations for changing office workers' sitting time: results from the Stand@Work randomized controlled trial pilot. *Int J Behav Nutr Phys Act, 11*, 127. doi:10.1186/s12966-014-0127-7

Chau, J. Y., Sukala, W., Fedel, K., Do, A., Engelen, L., Kingham, M., . . . Bauman, A. E. (2016). More standing and just as productive: Effects of a sit-stand desk intervention on call center workers' sitting, standing, and productivity at work in the Opt to Stand pilot study. *Preventive medicine reports, 3*, 68-74. Retrieved from http://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=cctr&AN=CN-01161886

Church, T. S., Thomas, D. M., Tudor-Locke, C., Katzmarzyk, P. T., Earnest, C. P., Rodarte, R. Q., . . . Bouchard, C. (2011). Trends over 5 Decades in U.S. Occupation-Related Physical Activity and Their Associations with Obesity. *PLoS One, 6*(5), e19657. doi:10.1371/journal.pone.0019657

Clemes, S. A., Houdmont, J., Munir, F., Wilson, K., Kerr, R., & Addley, K. (2015). Descriptive epidemiology of domain-specific sitting in working adults: the Stormont Study. *Journal of Public Health, 38*(1), 53-60. doi:10.1093/pubmed/fdu114

Coenen, P., Willenberg, L., Parry, S., Shi, J. W., Romero, L., Blackwood, D. M., . . . Straker, L. M. (2018). Associations of occupational standing with musculoskeletal symptoms: a systematic review with meta-analysis. *British Journal of Sports Medicine, 52*(3), 176-183. doi:10.1136/bjsports-2016-096795

Commissaris, D. A., Konemann, R., Hiemstra-van Mastrigt, S., Burford, E. M., Botter, J., Douwes, M., & Ellegast, R. P. (2014). Effects of a standing and three dynamic workstations on computer task performance and cognitive function tests. *Applied Ergonomics, 45*(6), 1570-1578. Retrieved from http://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=cctr&AN=CN-01115709

Cox, R. H., Guth, J., Siekemeyer, L., Kellems, B., Brehm, S. B., & Ohlinger, C. M. (2011). Metabolic cost and speech quality while using an active workstation. *Journal of Physical Activity and Health, 8*(3), 332-339. Retrieved from http://journals.humankinetics.com/AfcStyle/DocumentDownload.cfm?DType=DocumentItem&Document=03%5Fcox%5FJPAH%5F2009%5F0092%2Epdf
http://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=emed13&AN=361317902
http://opurl.bib.umontreal.ca:9003/sfx_local?sid=OVID:embase&id=pmid:21487132&id=doi:&issn=1543-3080&isbn=&volume=8&issue=3&spage=332&pages=332-339&date=2011&title=Journal+of+Physical+Activity+and+Health&atitle=Metabolic+cost+and+speech+quality+while+using+an+active+workstation&aulast=Cox&pid=%3Cauthor%3ECox+R.H.%2CGuth+J.%2CSiekemeyer+L.%2CKe

llems+B.%2CBrehm+S.B.%2COhlinger+C.M.%3C%2Fauthor%3E%3CAN%3E361317902%3C%2FAN%3E%3CDT%3EJournal%3A+Article%3C%2FDT%3E<195. >

Crespo, N. C., Mullane, S. L., Zeigler, Z. S., Buman, M. P., & Gaesser, G. A. (2016). Effects of Standing and Light-Intensity Walking and Cycling on 24-h Glucose. *Medicine & Science in Sports & Exercise, 48*(12), 2503-2511. doi:10.1249/mss.0000000000001062

da Costa, B. G. G., da Silva, K. S., George, A. M., & de Assis, M. A. A. (2017). Sedentary behavior during school-time: Sociodemographic, weight status, physical education class, and school performance correlates in Brazilian schoolchildren. *Journal of Science and Medicine in Sport, 20*(1), 70-74. doi:https://doi.org/10.1016/j.jsams.2016.06.004

Davis, K. G., & Kotowski, S. E. (2014). Postural variability: an effective way to reduce musculoskeletal discomfort in office work. *Human factors, 56*(7), 1249-1261. Retrieved from http://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=emed16&AN=602088638

http://opurl.bib.umontreal.ca:9003/sfx_local?sid=OVID:embase&id=pmid:25490805&id=doi:&issn=0018-7208&isbn=&volume=56&issue=7&spage=1249&pages=1249-1261&date=2014&title=Human+factors&atitle=Postural+variability%3A+an+effective+way+to+reduce+musculoskeletal+discomfort+in+office+work&aulast=Davis&pid=%3Cauthor%3EDavis+K.G.%2CKotowski+S.E.%3C%2Fauthor%3E%3CAN%3E602088638%3C%2FAN%3E%3CDT%3EJournal%3A+Article%3C%2FDT%3E<124. >

Davis, K. G., & Kotowski, S. E. (2015). Stand Up and Move; Your Musculoskeletal Health Depends on It. *Ergonomics in Design, 23*(3), 9-13. doi:10.1177/1064804615588853

DicoLatin©. (2012). DicoLatin. Retrieved from http://www.dicolatin.com/FR/LAK/0/SEDERE/index.htm

Ding, D., Lawson, K. D., Kolbe-Alexander, T. L., Finkelstein, E. A., Katzmarzyk, P. T., van Mechelen, W., & Pratt, M. (2016). The economic burden of physical inactivity:

a global analysis of major non-communicable diseases. *The Lancet, 388*(10051), 1311-1324. doi:10.1016/S0140-6736(16)30383-X

Drury, C. G., Hsiao, Y. L., Joseph, C., Joshi, S., Lapp, J., & Pennathur, P. R. (2008). Posture and performance: sitting vs. standing for security screening. *Ergonomics, 51*(3), 290-307. doi:10.1080/00140130701628790

Dupont, F., Léger, P.-M., Begon, M., Lecot, F., Sénécal, S., Labonté-Lemoyne, E., & Mathieu, M.-E. (2019). Health and productivity at work: which active workstation for which benefits: a systematic review. *Occupational and Environmental Medicine, 76*(5), 281. doi:10.1136/oemed-2018-105397

Dutta, N., Koepp, G. A., Stovitz, S. D., Levine, J. A., & Pereira, M. A. (2014). Using Sit-Stand Workstations to Decrease Sedentary Time in Office Workers: A Randomized Crossover Trial. *International journal of environmental research and public health, 11*(7), 6653-6665. Retrieved from https://www.mdpi.com/1660-4601/11/7/6653

Edelson, N., & Danoffz, J. (1989). Walking on an electric treadmill while performing VDT office work. *SIGCHI Bull., 21*(1), 72-77. doi:10.1145/67880.67890

Ee, J., Parry, S., Oliveira, B. I. d., McVeigh, J. A., Howie, E., & Straker, L. (2018). Does a Classroom Standing Desk Intervention Modify Standing and Sitting Behaviour and Musculoskeletal Symptoms during School Time and Physical Activity during Waking Time? *International journal of environmental research and public health, 15*(8), 1668. doi:10.3390/ijerph15081668

Ekman, A., Andersson, A., Hagberg, M., & Hjelm, E. W. (2000). Gender Differences in Musculoskeletal Health of Computer and Mouse Users in the Swedish Workforce. *Occupational Medicine, 50*(8), 608-613. doi:10.1093/occmed/50.8.608

Elmer, S. J., & Martin, J. C. (2014). A cycling workstation to facilitate physical activity in office settings. *Applied Ergonomics, 45*(4), 1240-1246. doi:https://doi.org/10.1016/j.apergo.2014.03.001

Evans, R. E., Fawole, H. O., Sheriff, S. A., Dall, P. M., Grant, P. M., & Ryan, C. G. (2012). Point-of-Choice Prompts to Reduce Sitting Time at Work: A Randomized Trial. *American Journal of Preventive Medicine, 43*(3), 293-297. doi:https://doi.org/10.1016/j.amepre.2012.05.010

Fedorowich, L. M., Emery, K., & Cote, J. N. (2015). The effect of walking while typing on neck/shoulder patterns. *European Journal of Applied Physiology, 115*(8), 1813-1823. doi:10.1007/s00421-015-3163-3

Fisher, A., Sawyer, A., Wardle, J., Smith, L., McCourt, O., Marmot, A., & Ucci, M. (2016). A review of occupational physical activity and sedentary behaviour correlates. *Occupational Medicine, 66*(3), 185-192. doi:10.1093/occmed/kqv164

Funk, R. E., Taylor, M. L., Creekmur, C. C., Ohlinger, C. M., Cox, R. H., & Berg, W. P. (2012). Effect of walking speed on typing performance using an active workstation. *Perceptual and motor skills, 115*(1), 309-318. doi:http://dx.doi.org/10.2466/06.23.26.PMS.115.4.309-318

Gilson, N. D., Hall, C., Renton, A., Ng, N., & Hippel, W. v. (2017). Do Sitting, Standing or Treadmill Desks Impact Psychobiological Indicators of Work Productivity? *Journal of Physical Activity and Health, 0*(0), 1-16. doi:10.1123/jpah.2016-0712

Grace, M. S., Formosa, M. F., Bozaoglu, K., Bergouignan, A., Brozynska, M., Carey, A. L., . . . Kingwell, B. A. (2019). Acute effects of active breaks during prolonged sitting on subcutaneous adipose tissue gene expression: an ancillary analysis of a randomised controlled trial. *Scientific Reports, 9*(1), 3847. doi:10.1038/s41598-019-40490-0

Hadgraft, N. T., Brakenridge, C. L., LaMontagne, A. D., Fjeldsoe, B. S., Lynch, B. M., Dunstan, D. W., . . . Lawler, S. P. (2016). Feasibility and acceptability of reducing workplace sitting time: a qualitative study with Australian office workers. *BMC Public Health, 16*, 933. doi:10.1186/s12889-016-3611-y

Hallman, D., Mathiassen, S., Gupta, N., Korshøj, M., & Holtermann, A. (2015). Differences between work and leisure in temporal patterns of objectively measured physical activity among blue-collar workers. *BMC Public Health, 15*. doi:10.1186/s12889-015-2339-4

Hamilton, M. T., Hamilton, D. G., & Zderic, T. W. (2007). Role of Low Energy Expenditure and Sitting in Obesity, Metabolic Syndrome, Type 2 Diabetes, and Cardiovascular Disease. *Diabetes, 56*(11), 2655-2667. doi:10.2337/db07-0882

Hamilton, M. T., Healy, G. N., Dunstan, D. W., Zderic, T. W., & Owen, N. (2008). Too Little Exercise and Too Much Sitting: Inactivity Physiology and the Need for New

Recommendations on Sedentary Behavior. *Current cardiovascular risk reports, 2*(4), 292-298. doi:10.1007/s12170-008-0054-8

Hasegawa, T., Inoue, K., Tsutsue, O., & Kumashiro, M. (2001). *Effects of a sit–stand schedule on a light repetitive task* (Vol. 28).

Healy, G. N., Dunstan, D. W., Salmon, J., Cerin, E., Shaw, J. E., Zimmet, P. Z., & Owen, N. (2008). Breaks in Sedentary Time. *Diabetes Care, 31*(4), 661. doi:10.2337/dc07-2046

Healy, G. N., Eakin, E. G., LaMontagne, A. D., Owen, N., Winkler, E. A. H., Wiesner, G., . . . Dunstan, D. W. (2013). Reducing sitting time in office workers: Short-term efficacy of a multicomponent intervention. *Preventive Medicine, 57*(1), 43-48. doi:https://doi.org/10.1016/j.ypmed.2013.04.004

Healy, G. N., Eakin, E. G., Owen, N., LaMontagne, A. D., Moodie, M., Winkler, E. A., . . . Dunstan, D. W. (2016). A Cluster RCT to Reduce Office Workers' Sitting Time: Impact on Activity Outcomes. *Med Sci Sports Exerc*. doi:10.1249/mss.0000000000000972

Healy, G. N., Matthews, C. E., Dunstan, D. W., Winkler, E. A. H., & Owen, N. (2011). Sedentary time and cardio-metabolic biomarkers in US adults: NHANES 2003–06. *European Heart Journal, 32*(5), 590-597. doi:10.1093/eurheartj/ehq451

Herman Hansen, B., Børtnes, I., Hildebrand, M., Holme, I., Kolle, E., & Anderssen, S. A. (2014). Validity of the ActiGraph GT1M during walking and cycling. *Journal of Sports Sciences, 32*(6), 510-516. doi:10.1080/02640414.2013.844347

Hinckson, E., Salmon, J., Benden, M., Clemes, S., Sudholz, B., Barber, S., . . . Ridgers, N. (2015). Standing Classrooms: Research and Lessons Learned from Around the World. *Sports Medicine, 46*. doi:10.1007/s40279-015-0436-2

Holtermann, A., Krause, N., van der Beek, A. J., & Straker, L. (2018). The physical activity paradox: six reasons why occupational physical activity (OPA) does not confer the cardiovascular health benefits that leisure time physical activity does. *British Journal of Sports Medicine, 52*(3), 149. doi:10.1136/bjsports-2017-097965

Holtermann, A., Mathiassen, S., & Straker, L. (2019). Promoting health and physical capacity during productive work: the Goldilocks Principle. *Scandinavian Journal of Work, Environment & Health*(1), 90-97. doi:10.5271/sjweh.3754

HOWARD, B. J., FRASER, S. F., SETHI, P., CERIN, E., HAMILTON, M. T., OWEN, N., . . . KINGWELL, B. A. (2013). Impact on Hemostatic Parameters of Interrupting Sitting with Intermittent Activity. *Medicine & Science in Sports & Exercise, 45*(7), 1285-1291. doi:10.1249/MSS.0b013e318285f57e

Huang, T., Gu, Q., Deng, Z., Tsai, C., Xue, Y., Zhang, J., . . . Wang, K. (2019). Executive Function Performance in Young Adults When Cycling at an Active Workstation: An fNIRS Study. *International Journal of Environmental Research and Public Health, 16*(7), 1119. doi:10.3390/ijerph16071119

Husemann, B., Von Mach, C. Y., Borsotto, D., Zepf, K. I., & Scharnbacher, J. (2009). Comparisons of musculoskeletal complaints and data entry between a sitting and a sit-stand workstation paradigm. *Hum Factors, 51*(3), 310-320. doi:10.1177/0018720809338173

Hutcheson, A. K., Piazza, A. J., & Knowlden, A. P. (2018). Work Site-Based Environmental Interventions to Reduce Sedentary Behavior: A Systematic Review. *Am J Health Promot, 32*(1), 32-47. doi:10.1177/0890117116674681

Huysmans, M. A., Blatter, B. M., & van der Beek, A. J. (2012). Perceived muscular tension predicts future neck–shoulder and arm–wrist–hand symptoms. *Occupational and Environmental Medicine, 69*(4), 261. doi:10.1136/oemed-2011-100279

Janssen, I. (2012). Health care costs of physical inactivity in Canadian adults. *Applied Physiology, Nutrition, and Metabolism, 37*(4), 803-806. doi:10.1139/h2012-061

Josaphat, K.-J., Kugathasan, T. A., E.R. Reid, R., Begon, M., Léger, P.-M., Labonté-Lemoyne, E., . . . Mathieu, M.-E. (2019). Use of Active Workstations in Individuals with Overweight or Obesity: A Systematic Review. *Obesity, 27*(3), 362-379. doi:10.1002/oby.22388

Kalkis, H. (2015). Economic Analytical Methods for Work-related MSD Cost Prediction. *Procedia Manufacturing, 3*, 4181-4188. doi:https://doi.org/10.1016/j.promfg.2015.07.393

Karakolis, T., & Callaghan, J. P. (2014). The impact of sit–stand office workstations on worker discomfort and productivity: A review. *Applied Ergonomics, 45*(3), 799-806. doi:https://doi.org/10.1016/j.apergo.2013.10.001

Kazi, A., Duncan, M., Clemes, S., & Haslam, C. (2014). A survey of sitting time among UK employees. *Occupational Medicine, 64*(7), 497-502. doi:10.1093/occmed/kqu099

Keadle, S. K., Conroy, D. E., Buman, M. P., Dunstan, D. W., & Matthews, C. E. (2017). Targeting Reductions in Sitting Time to Increase Physical Activity and Improve Health. *Medicine and science in sports and exercise, 49*(8), 1572-1582. doi:10.1249/MSS.0000000000001257

Larson, M. J., LeCheminant, J. D., Hill, K., Carbine, K., Masterson, T., & Christenson, E. (2015). Cognitive and Typing Outcomes Measured Simultaneously with Slow Treadmill Walking or Sitting: Implications for Treadmill Desks. *PLOS ONE, 10*(4), e0121309. doi:10.1371/journal.pone.0121309

Lederer, V., Rivard, M., & Mechakra-Tahiri, S. D. (2012). Gender Differences in Personal and Work-Related Determinants of Return-to-Work Following Long-Term Disability: A 5-Year Cohort Study. *Journal of Occupational Rehabilitation, 22*(4), 522-531. doi:10.1007/s10926-012-9366-0

Lin, M. Y., Barbir, A., & Dennerlein, J. T. (2017). Evaluating biomechanics of user-selected sitting and standing computer workstation. *Applied Ergonomics, 65*, 382-388. doi:https://doi.org/10.1016/j.apergo.2017.04.006

Lindberg, C. M., Srinivasan, K., Gilligan, B., Razjouyan, J., Lee, H., Najafi, B., . . . Sternberg, E. M. (2018). Effects of office workstation type on physical activity and stress. *Occupational and Environmental Medicine, 75*(10), 689. doi:10.1136/oemed-2018-105077

MacEwen, B. T., MacDonald, D. J., & Burr, J. F. (2015). A systematic review of standing and treadmill desks in the workplace. *Preventive Medicine, 70*, 50-58. doi:https://doi.org/10.1016/j.ypmed.2014.11.011

Mackie, P., Weerasekara, I., Crowfoot, G., Janssen, H., Holliday, E., Dunstan, D., & English, C. (2019). What is the effect of interrupting prolonged sitting with frequent bouts of physical activity or standing on first or recurrent stroke risk factors? A scoping review. *PLOS ONE, 14*(6), e0217981-e0217981. doi:10.1371/journal.pone.0217981

Macpherson, R. A., Koehoorn, M., Fan, J., Quirke, W., Amick, B. C., Kraut, A., . . . McLeod, C. B. (2019). Do Differences in Work Disability Duration Between Men and

Women Vary by Province in Canada? *Journal of Occupational Rehabilitation, 29*(3), 560-568. doi:10.1007/s10926-018-9819-1

Madeleine, P., Vangsgaard, S., Hviid Andersen, J., Ge, H.-Y., & Arendt-Nielsen, L. (2013). Computer work and self-reported variables on anthropometrics, computer usage, work ability, productivity, pain, and physical activity. *BMC Musculoskeletal Disorders, 14*(1), 226. doi:10.1186/1471-2474-14-226

Mansoubi, M., Pearson, N., Biddle, S. J., & Clemes, S. A. (2016). Using Sit-to-Stand Workstations in Offices: Is There a Compensation Effect? *Med Sci Sports Exerc, 48*(4), 720-725. doi:10.1249/mss.0000000000000802

Mansoubi, M., Pearson, N., Biddle, S. J. H., & Clemes, S. (2014). The relationship between sedentary behaviour and physical activity in adults: A systematic review. *Preventive Medicine, 69*, 28-35. doi:https://doi.org/10.1016/j.ypmed.2014.08.028

Martin, A., Fitzsimons, C., Jepson, R., Saunders, D. H., van der Ploeg, H. P., Teixeira, P. J., . . . Mutrie, N. (2015). Interventions with potential to reduce sedentary time in adults: systematic review and meta-analysis. *British Journal of Sports Medicine*. doi:10.1136/bjsports-2014-094524

Mehta, R., Shortz, A., & Benden, M. (2015). Standing Up for Learning: A Pilot Investigation on the Neurocognitive Benefits of Stand-Biased School Desks. *International journal of environmental research and public health, 13*. doi:10.3390/ijerph13010059

Morris, J. N., Heady, J.A, Raffle, P.A,B, Roberts,C.G., Parks, J.W. (1953). Coronary heart disease and physical activity of work. *Lancet, 265*.

Mullane, S. L., Buman, M. P., Zeigler, Z. S., Crespo, N. C., & Gaesser, G. A. (2017). Acute effects on cognitive performance following bouts of standing and light-intensity physical activity in a simulated workplace environment. *J Sci Med Sport, 20*(5), 489-493. doi:10.1016/j.jsams.2016.09.015

Nam, J. Y., Kim, J., Cho, K. H., Choi, J., Shin, J., & Park, E.-C. (2017). The impact of sitting time and physical activity on major depressive disorder in South Korean adults: a cross-sectional study. *BMC Psychiatry, 17*(1), 274. doi:10.1186/s12888-017-1439-3

National Institute for Health and Care Excellence. (2008). Physical activity in the workplace. Retrieved from https://www.nice.org.uk/guidance/ph13

Neuhaus, M., Eakin, E. G., Straker, L., Owen, N., Dunstan, D. W., Reid, N., & Healy, G. N. (2014a). Reducing occupational sedentary time: a systematic review and meta-analysis of evidence on activity-permissive workstations. *Obesity reviews : an official journal of the International Association for the Study of Obesity, 15*(10), 822-838. doi:10.1111/obr.12201

Neuhaus, M., Eakin, E. G., Straker, L., Owen, N., Dunstan, D. W., Reid, N., & Healy, G. N. (2014b). Reducing occupational sedentary time: a systematic review and meta-analysis of evidence on activity-permissive workstations. *Obesity Reviews, 15*(10), 822-838. doi:10.1111/obr.12201

Ng, S. W., & Popkin, B. M. (2012). Time use and physical activity: a shift away from movement across the globe. *Obesity Reviews, 13*(8), 659-680. doi:10.1111/j.1467-789X.2011.00982.x

Ohlinger, C. M., Horn, T. S., Berg, W. P., & Cox, R. H. (2011). The effect of active workstation use on measures of cognition, attention, and motor skill. *J Phys Act Health, 8*(1), 119-125.

Ojo, S. O., Bailey, D. P., Chater, A. M., & Hewson, D. J. (2018). The Impact of Active Workstations on Workplace Productivity and Performance: A Systematic Review. *International Journal of Environmental Research and Public Health, 15*(3), 417. doi:10.3390/ijerph15030417

Owen, N., Bauman, A., & Brown, W. (2009). Too much sitting: a novel and important predictor of chronic disease risk? *British Journal of Sports Medicine, 43*(2), 81. Retrieved from http://bjsm.bmj.com/content/43/2/81.abstract

Owen, N., Healy, G. N., Matthews, C. E., & Dunstan, D. W. (2010). Too Much Sitting: The Population-Health Science of Sedentary Behavior. *Exercise and Sport Sciences Reviews, 38*(3), 105-113. doi:10.1097/JES.0b013e3181e373a2

Owen, N., Sparling, P. B., Healy, G. N., Dunstan, D. W., & Matthews, C. E. (2010). Sedentary behavior: emerging evidence for a new health risk. *Mayo Clinic proceedings, 85*(12), 1138-1141. doi:10.4065/mcp.2010.0444

Owen, N., & Zhu, W. (2017). *Sedentary behavior and health : concepts, assessments, and interventions*: Champaign : Human Kinetics.

Palumbo, A., J. De Roos, A., Cannuscio, C., Robinson, L., Mossey, J., Weitlauf, J., . . . Michael, Y. (2017). Work Characteristics Associated with Physical Functioning in Women. *International journal of environmental research and public health, 14*, 424. doi:10.3390/ijerph14040424

Parry, S., & Straker, L. (2013). The contribution of office work to sedentary behaviour associated risk. *BMC Public Health, 13*(1), 296. doi:10.1186/1471-2458-13-296

Pate, R. R., O'Neill, J. R., & Lobelo, F. (2008). The Evolving Definition of "Sedentary". *Exercise and Sport Sciences Reviews, 36*(4), 173-178. doi:10.1097/JES.0b013e3181877d1a

Peddie, M. C., Bone, J. L., Rehrer, N. J., Skeaff, C. M., Gray, A. R., & Perry, T. L. (2013). Breaking prolonged sitting reduces postprandial glycemia in healthy, normal-weight adults: a randomized crossover trial. *The American Journal of Clinical Nutrition, 98*(2), 358-366. doi:10.3945/ajcn.112.051763

Pilcher, J. J., & Baker, V. C. (2016). Task Performance and Meta-Cognitive Outcomes When Using Activity Workstations and Traditional Desks. *Front Psychol, 7*, 957. doi:10.3389/fpsyg.2016.00957

Podrekar, N., Kozinc, Ž., & Šarabon, N. (2018). Effects of cycle and treadmill desks on energy expenditure and cardiometabolic parameters in sedentary workers: review and meta-analysis. *International Journal of Occupational Safety and Ergonomics*, 1-9. doi:10.1080/10803548.2018.1562688

Prince, S. A., Saunders, T. J., Gresty, K., & Reid, R. D. (2014). A comparison of the effectiveness of physical activity and sedentary behaviour interventions in reducing sedentary time in adults: a systematic review and meta-analysis of controlled trials. *Obesity reviews : an official journal of the International Association for the Study of Obesity, 15*(11), 905-919. doi:10.1111/obr.12215

Pronk, N. P., Katz, A. S., Lowry, M., & Payfer, J. R. (2012). Reducing occupational sitting time and improving worker health: the Take-a-Stand Project, 2011. *Prev Chronic Dis, 9*, E154. doi:10.5888.pcd9.110323

Public health agency of Canada. (2017-03-16). Government of Canada invests in program to combat sedentary behaviour in the workplace. Retrieved from https://www.canada.ca/en/public-health/news/2017/03/government_of_canadainvestsinprogramtocombatsedentarybehaviourin.html

Puig-Ribera, A., Martínez-Lemos, I., Giné-Garriga, M., González-Suárez, Á. M., Bort-Roig, J., Fortuño, J., . . . Gilson, N. D. (2015). Self-reported sitting time and physical activity: interactive associations with mental well-being and productivity in office employees. *BMC Public Health, 15*(1), 72. doi:10.1186/s12889-015-1447-5

Pulsford, R. M., Blackwell, J., Hillsdon, M., & Kos, K. (2017). Intermittent walking, but not standing, improves postprandial insulin and glucose relative to sustained sitting: A randomised cross-over study in inactive middle-aged men. *Journal of Science and Medicine in Sport, 20*(3), 278-283. doi:https://doi.org/10.1016/j.jsams.2016.08.012

Qin, L., Sun, X., Liu, B., & Leyva, L. M. (2019, 2019//). *When to Take a Break? Exploring the Role of Peers on Sedentary Office Workers' Resting Behaviors.* Paper presented at the HCI International 2019 – Late Breaking Papers, Cham.

Reiff, C., Marlatt, K., & Dengel, D. R. (2012). Difference in Caloric Expenditure in Sitting Versus Standing Desks. *Journal of Physical Activity and Health, 9*(7), 1009-1011. doi:10.1123/jpah.9.7.1009

Renaud, L. R., Huysmans, M. A., van der Ploeg, H. P., Speklé, E. M., & van der Beek, A. J. (2018). Long-Term Access to Sit-Stand Workstations in a Large Office Population: User Profiles Reveal Differences in Sitting Time and Perceptions. *International journal of environmental research and public health, 15*(9), 2019. doi:10.3390/ijerph15092019

Rezende, L. F. M. d., Rey-López, J. P., Matsudo, V. K. R., & Luiz, O. d. C. (2014). Sedentary behavior and health outcomes among older adults: a systematic review. *BMC Public Health, 14*(1), 333. doi:10.1186/1471-2458-14-333

Ryan, C. G., Dall, P. M., Granat, M. H., & Grant, P. M. (2011). Sitting patterns at work: objective measurement of adherence to current recommendations. *Ergonomics, 54*(6), 531-538. doi:10.1080/00140139.2011.570458

Ryde, G. C., Brown, H. E., Gilson, N. D., & Brown, W. J. (2014). Are We Chained to Our Desks? Describing Desk-Based Sitting Using a Novel Measure of Occupational

Sitting. *Journal of Physical Activity and Health, 11*(7), 1318-1323. doi:10.1123/jpah.2012-0480

Salmon, J., Owen, N., Crawford, D., Bauman, A., & Sallis, J. F. (2003). Physical activity and sedentary behavior: A population-based study of barriers, enjoyment, and preference. *Health Psychology, 22*(2), 178-188. doi:10.1037/0278-6133.22.2.178

Salmon, J., Tremblay, M. S., Marshall, S. J., & Hume, C. (2011). Health Risks, Correlates, and Interventions to Reduce Sedentary Behavior in Young People. *American Journal of Preventive Medicine, 41*(2), 197-206. doi:https://doi.org/10.1016/j.amepre.2011.05.001

Sarver, D. E., Rapport, M. D., Kofler, M. J., Raiker, J. S., & Friedman, L. M. (2015). Hyperactivity in Attention-Deficit/Hyperactivity Disorder (ADHD): Impairing Deficit or Compensatory Behavior? *Journal of Abnormal Child Psychology, 43*(7), 1219-1232. doi:10.1007/s10802-015-0011-1

Shrestha, N., Kukkonen-Harjula, K. T., Verbeek, J. H., Ijaz, S., Hermans, V., & Bhaumik, S. (2016). Workplace interventions for reducing sitting at work. *Cochrane Database of Systematic Reviews*(3). doi:10.1002/14651858.CD010912.pub3

Shrestha, N., Kukkonen-Harjula, K. T., Verbeek, J. H., Ijaz, S., Hermans, V., & Pedisic, Z. (2018). Workplace interventions for reducing sitting at work. *Cochrane Database of Systematic Reviews*(6). doi:10.1002/14651858.CD010912.pub4

Sliter, M., & Yuan, Z. (2015). Workout at work: Laboratory test of psychological and performance outcomes of active workstations. *Journal of occupational health psychology, 20*(2), 259-271. Retrieved from http://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=cctr&AN=CN-01087573

Statistics Canada. (2017). Daily average time spent in hours on various activities by age group and sex, 15 years and over, Canada and provinces. In T. 45-10-0014-01 (Ed.). General Social Survey - Time Use (GSS).

Straker, L. (2019). Evidence to design 'just right' work using active workstations is currently limited. *Occupational and Environmental Medicine, 76*(5), 279. doi:10.1136/oemed-2018-105671

Straker, L., Levine, J., & Campbell, A. (2009). The effects of walking and cycling computer workstations on keyboard and mouse performance. *Human factors, 51*(6), 831-844. doi:http://dx.doi.org/10.1177/0018720810362079

Straker, L., & Mathiassen, S. E. (2009). Increased physical work loads in modern work – a necessity for better health and performance? *Ergonomics, 52*(10), 1215-1225. doi:10.1080/00140130903039101

Thompson, W. G., & Levine, J. A. (2011). Productivity of transcriptionists using a treadmill desk. *Work (Reading, Mass.), 40*(4), 473-477. Retrieved from http://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=emed13&AN=560064824 http://opurl.bib.umontreal.ca:9003/sfx_local?sid=OVID:embase&id=pmid:22130064&id=doi:&issn=1875-9270&isbn=&volume=40&issue=4&spage=473&pages=473-477&date=2011&title=Work+%28Reading%2C+Mass.%29&atitle=Productivity+of+transcriptionists+using+a+treadmill+desk&aulast=Thompson&pid=%3Cauthor%3EThompson+W.G.%2CLevine+J.A.%3C%2Fauthor%3E%3CAN%3E560064824%3C%2FAN%3E%3CDT%3EJournal%3A+Article%3C%2FDT%3E<188. >

Toomingas, A., Forsman, M., Mathiassen, S., Heiden, M., & Nilsson, T. (2012). Variation between seated and standing/walking postures among male and female call centre operators. *BMC Public Health, 12*, 154. doi:10.1186/1471-2458-12-154

Torbeyns, T., Bailey, S., Bos, I., & Meeusen, R. (2014). Active Workstations to Fight Sedentary Behaviour. *Sports Medicine, 44*(9), 1261-1273. doi:10.1007/s40279-014-0202-x

Torbeyns, T., de Geus, B., Bailey, S., De Pauw, K., Decroix, L., Van Cutsem, J., & Meeusen, R. (2016). Cycling on a Bike Desk Positively Influences Cognitive Performance. *PLoS One, 11*(11), e0165510. doi:10.1371/journal.pone.0165510

Torbeyns, T., de Geus, B., Bailey, S., Decroix, L., Van Cutsem, J., De Pauw, K., & Meeusen, R. (2017). Bike Desks in the Classroom: Energy Expenditure, Physical Health, Cognitive Performance, Brain Functioning, and Academic Performance. *J Phys Act Health, 14*(6), 429-439. doi:10.1123/jpah.2016-0224

Tremblay, M. S., Aubert, S., Barnes, J. D., Saunders, T. J., Carson, V., Latimer-Cheung, A. E., . . . on behalf of, S. T. C. P. P. (2017). Sedentary Behavior Research Network

(SBRN) – Terminology Consensus Project process and outcome. *International Journal of Behavioral Nutrition and Physical Activity, 14*(1), 75. doi:10.1186/s12966-017-0525-8

Tronarp, R., Nyberg, A., #xe9, Hedlund, M., #xe4, ger, C. K., . . . rklund, M. (2018). Office-Cycling: A Promising Way to Raise Pain Thresholds and Increase Metabolism with Minimal Compromising of Work Performance. *BioMed Research International, 2018*, 12. doi:10.1155/2018/5427201

Tudor-Locke, C., Schuna, J. M., Frensham, L. J., & Proenca, M. (2014). Changing the way we work: elevating energy expenditure with workstation alternatives. *Int J Obes, 38*(6), 755-765. doi:10.1038/ijo.2013.223

U.S. Bureau of Labor Statistics. (2018). PHYSICAL DEMANDS OF CIVILIAN WORKERS. Retrieved from https://www.bls.gov/ors/latest-numbers.htm

U.S. Department of Health & Human Services. (2010). Assessing Your Weight and Health Risk. Retrieved from https://www.nhlbi.nih.gov/health/educational/lose_wt/risk.htm

van Stralen, M. M., Yıldırım, M., Wulp, A., te Velde, S. J., Verloigne, M., Doessegger, A., . . . Chinapaw, M. J. M. (2014). Measured sedentary time and physical activity during the school day of European 10- to 12-year-old children: The ENERGY project. *Journal of Science and Medicine in Sport, 17*(2), 201-206. doi:https://doi.org/10.1016/j.jsams.2013.04.019

Wahlström, J. (2005). Ergonomics, musculoskeletal disorders and computer work. *Occupational Medicine, 55*(3), 168-176. doi:10.1093/occmed/kqi083

Wahlström, J., Hagberg, M., Toomingas, A., & Wigaeus Tornqvist, E. (2004). Perceived muscular tension, job strain, physical exposure, and associations with neck pain among VDU users; a prospective cohort study. *Occupational and Environmental Medicine, 61*(6), 523. doi:10.1136/oem.2003.009563

Waters, C. N., Ling, E. P., Chu, A. H. Y., Ng, S. H. X., Chia, A., Lim, Y. W., & Müller-Riemenschneider, F. (2016). Assessing and understanding sedentary behaviour in office-based working adults: a mixed-method approach. *BMC Public Health, 16*, 360-360. doi:10.1186/s12889-016-3023-z

Wilmot, E. G., Edwardson, C. L., Achana, F. A., Davies, M. J., Gorely, T., Gray, L. J., . . . Biddle, S. J. H. (2012). Sedentary time in adults and the association with diabetes, cardiovascular disease and death: systematic review and meta-analysis. *Diabetologia, 55*(11), 2895-2905. doi:10.1007/s00125-012-2677-z

World Health Organization. (2008). Physical Inactivity: A Global Public Health Problem. Retrieved from https://www.who.int/dietphysicalactivity/factsheet_inactivity/en/

World Health Organization. (2019). Obesity and overweight. Retrieved from https://www.who.int/en/news-room/fact-sheets/detail/obesity-and-overweight

Yoon, S., Lefrançois-Daignault, T., & Côté, J. N. (2019). Effects of cycling while typing on upper limb and performance characteristics. *Applied Ergonomics, 80*, 161-167. doi:https://doi.org/10.1016/j.apergo.2019.05.015

Zeigler, Z. S., Mullane, S. L., Crespo, N. C., Buman, M. P., & Gaesser, G. A. (2016). Effects of Standing and Light-Intensity Activity on Ambulatory Blood Pressure. *Med Sci Sports Exerc, 48*(2), 175-181. doi:10.1249/mss.0000000000000754

Zhai, L., Zhang, Y., & Zhang, D. (2015). Sedentary behaviour and the risk of depression: a meta-analysis. *British Journal of Sports Medicine, 49*(11), 705. doi:10.1136/bjsports-2014-093613

Zhang, Z., Zhang, B., Cao, C., & Chen, W. (2018). The effects of using an active workstation on executive function in Chinese college students. *PLOS ONE, 13*(6), e0197740-e0197740. doi:10.1371/journal.pone.0197740

Zhu, W., Gutierrez, M., Toledo, M. J., Mullane, S., Stella, A. P., Diemar, R., . . . Buman, M. P. (2018). Long-term effects of sit-stand workstations on workplace sitting: A natural experiment. *Journal of Science and Medicine in Sport, 21*(8), 811-816. doi:https://doi.org/10.1016/j.jsams.2017.12.005