HEC MONTRÉAL

La demande physique et la performance en contexte d'utilisation de bureaux actifs lors de tâches impliquant l'utilisation des TI

Par
Marc-Antoine Jutras

Sciences de la gestion
(Technologies de l'information)

Mémoire présenté en vue de l'obtention
du grade de maîtrise ès sciences
(M.Sc.)

Décembre 2017

HEC MONTRĒAL

Comité d'éthique de la recherche

Le 02 février 2017

À l'attention de : Pierre-Majorique Leger
Technologies de l'information, Professeur titulaire,
HEC Montréal

Objet : Approbation éthique de votre projet de recherche

 # Projet : 2017-2440

Titre du projet de recherche : L'attention et la productivité lors de l'utilisation d'un bureau debout

Financé par le CRSH et le CRSNG

Votre projet de recherche a fait l'objet d'une évaluation en matière d'éthique de la recherche avec des êtres humains par le CER de HEC Montréal.

Un certificat d'approbation éthique qui atteste de la conformité de votre projet de recherche à la *Politique relative à l'éthique de la recherche avec des êtres humains* de HEC Montréal est émis en date du 02 février 2017. Prenez note que ce certificat est **valide jusqu'au 01 février 2018.**

Vous devrez obtenir le renouvellement de votre approbation éthique avant l'expiration de ce certificat à l'aide du formulaire *F7 - Renouvellement annuel.* Un rappel automatique vous sera envoyé par courriel quelques semaines avant l'échéance de votre certificat.

Si des modifications sont apportées à votre projet avant l'échéance du certificat, vous devrez remplir le formulaire *F8 - Modification de projet* et obtenir l'approbation du CER avant de mettre en oeuvre ces modifications. Si votre projet est terminé avant l'échéance du certificat, vous devrez remplir le formulaire *F9 - Fin de projet ou F9a - Fin de projet étudiant*, selon le cas.

Notez qu'en vertu de la *Politique relative à l'éthique de la recherche avec des êtres humains de HEC Montréal*, il est de la responsabilité des chercheurs d'assurer que leurs projets de recherche conservent une approbation éthique pour toute la durée des travaux de recherche et d'informer le CER de la fin de ceux-ci. De plus, toutes modifications significatives du projet doivent être transmises au CER avant leurs applications.

Vous pouvez dès maintenant procéder à la collecte de données pour laquelle vous avez obtenu ce certificat.

Nous vous souhaitons bon succès dans la réalisation de votre recherche.

Le CER de HEC Montréal

HEC MONTRĒAL

Comité d'éthique de la recherche

ATTESTATION D'APPROBATION ÉTHIQUE COMPLÉTÉE

La présente atteste que le projet de recherche décrit ci-dessous a fait l'objet des approbations en matière d'éthique de la recherche avec des êtres humains nécessaires selon les exigences de HEC Montréal.

La période de validité du certificat d'approbation éthique émis pour ce projet est maintenant terminée. Si vous devez reprendre contact avec les participants ou reprendre une collecte de données pour ce projet, la certification éthique doit être réactivée préalablement. Vous devez alors prendre contact avec le secrétariat du CER de HEC Montréal.

Nom de l'étudiant : Marc-Antoine Jutras

Titre du projet supervisé/mémoire/thèse :
La demande physique et la performance en contexte d'utilisation de bureaux actifs lors de tâches impliquant l'utilisation des TI

Titre du projet sur le certificat :
L'attention et la productivité lors de l'utilisation d'un bureau debout

Projet # : 2017-2440

Chercheur principal / directeur de recherche :
Pierre-Majorique Léger

Cochercheurs :
David Brieugne; Elise Labonté-Lemoyne; Marc-Antoine Jutras; Sylvain Sénécal

Date d'approbation initiale du projet : 2 février 2017

Date de fermeture de l'approbation éthique pour l'étudiant(e) : 29 novembre 2017

Maurice Lemelin
Président du CER de HEC Montréal

NAGANO Document officiel du CER
Comité d'éthique de la recherche - HEC Montréal 1 / 1

Sommaire

Dans un contexte où les interactions avec les technologies lors de travail de bureautique s'effectuent en position assise, il est primordial d'adresser les enjeux reliés à la sédentarité. Ce mémoire a pour but d'étudier l'effet de la demande physique directe et indirecte sur la performance en contexte d'utilisation de bureaux actifs lors de tâches impliquant l'utilisation des TI. Ce mémoire est composé de deux articles. Dans un premier temps, une recherche exploratoire a été effectuée afin d'identifier la demande physique qui est générée par des tâches de travail de bureau. Onze participants ont fait treize tâches génériques de bureautique. Des mesures physiologiques ont été prises pour déterminer la demande physique directe. Dans un deuxième temps, la demande physique directe et indirecte ont été évaluées afin de déterminer leurs impacts sur la perception et la performance d'un utilisateur de technologie lors de l'utilisation d'un bureau assis-debout. Pour ce faire, une deuxième étude en laboratoire a été mise en place. Quarante participants ont été présentés à un stimulus dans huit conditions différentes variant selon la difficulté de la tâche (facile-difficile), la demande physique directe (haute-faible) et la demande physique indirecte (assis-debout). Des mesures psychométriques ont permis d'évaluer la perception et performance de l'utilisateur.

Les résultats de la première étude suggèrent qu'il y a un vaste spectre de demande physique qui est généré par les tâches de bureautique. Les extrêmes de tâche générant de la demande physique directe, soit le mouvement requis pour accomplir un objectif, sont les tâches nécessitant la souris (faible) et les tâches utilisant un écran tactile (élevé). La détermination de ces extrêmes permet d'évaluer la demande physique directe dans la deuxième étude. Les résultats de cette dernière suggèrent que la demande physique indirecte, le positionnement et mouvement du corps de l'utilisateur, n'influence pas la perception des utilisateurs et peu la performance. La demande physique directe a cependant un impact sur les variables de la perception et performance de l'utilisateur. Le modèle de recherche proposé est un premier pas vers une meilleure compréhension de l'impact de la demande physique sur la performance et perception des utilisateurs. Pour les gestionnaires, nos résultats peuvent aider à déterminer quel type de tâche doit être effectué sur ces postes actifs et contribuent à développer des stratégies pour lutter contre l'épidémie de sédentarité et d'obésité.

Mots clés : Demande physique, station actives assis-debout, interaction humaine machine, perception, difficulté de la tâche

Table des matières

Liste des Tableaux

Liste des figures

Remerciements

Je voudrais avant tout remercier toutes les personnes qui m'ont soutenue et accompagnée lors de ce parcours à la maîtrise et dans la réalisation de mon mémoire. Je remercie particulièrement mes directeurs de recherche Pierre-Majorique Léger et Sylvain Sénécal pour leurs commentaires, leur aide et partage de savoir scientifique. Grâce à vous, j'ai pu vivre des expériences qui m'ont forcé à me dépasser et à développer des compétences qui me seront fortement utiles sur le marché dans les prochaines années. Pierre-Majorique, merci pour ces deadlines pas toujours faciles, mais qui m'ont permis d'avancer rapidement. Merci pour votre confiance.

Également, j'aimerais remercier Élise Labonté-Lemoyne pour son support, sa présence et ses précieux conseils tout au long de mes recherches. Tu as su rendre la recherche plus agréable en transmettant ton intérêt pour ce domaine. Merci à tout le personnel du Tech3lab ayant aidé à aux étapes de mes projets.

Merci à tous mes collègues et amis de la M. Sc. et du B.A.A à HEC que j'ai côtoyées, notamment Horea et Théophile pour avoir partagé vos expériences similaires et pour vos encouragements. Un grand merci à Félix pour ses fameux conseils et sa sagesse. Merci à tous mes collègues du laboratoire ERPsim qui m'ont permis de garder un équilibre sain entre travail et école, tout au long de ma maîtrise

Merci à ma famille, Daniel, Lucie et Laurence, pour leur support inconditionnel, leurs encouragements et leur écoute pendante toutes ces années de ma scolarité. Vous avez toujours cru en moi, peu importe mes choix.

Je veux remercier mes amis qui m'ont changé les idées dans les moments plus difficiles, merci, Jonathan et Antoine, pour ces gins de fin de soirée. Finalement, merci à la personne la plus patiente que je connaisse, Anne-Sophie, qui malgré tout, m'a supporté dans tous mes projets.

Avant-propos

Sous l’approbation de la direction administrative du programme de la Maîtrise ès en gestion, ce mémoire a été écrit par articles. Le consentement de tous les coauteurs pour s’en servir dans le cadre de mon mémoire a été obtenu. L’approbation du CER de HEC Montréal a été donné pour effectuer une expérience au Tech3lab.Le premier article a été soumis et accepté à l’ASAC 2017, sur la demande physique directe d’une tâche TI. Le deuxième article soumis et accepté à la conférence Pre-ICIS Workshop on HCI et porte sur la performance et perception selon différents niveaux de demande physique directe et indirecte.

CHAPITRE 1: PROBLÉMATIQUE ET QUESTION DE RECHECHE

1.1 Mise en contexte

De nos jours, les utilisateurs des technologies de l'information (TI) peuvent effectuer des tâches en utilisant des appareils allant des ordinateurs de bureau aux téléphones cellulaires tout en étant assis ou en mouvement. En contexte de travail en entreprise, cette réalité est similaire. En effet, il est important de considérer l'utilisation d'outils mobiles (tablettes et cellulaires) qui semble de plus en plus importante (Okta, 2015). En creusant davantage sur l'aspect du travail de bureau, on remarque une hausse considérable de l'utilisation d'applications Cloud à titre d'outils technologiques telle la suite Microsoft Office 365 (Word, Excel, PPT, Access, etc.) (Okta, 2015) ce qui engendre une utilisation accrue des technologies.

Cependant, cette interaction avec les TI en organisation se fait principalement en position assise. On note que 65-75% du temps de travail est effectué assis sur des périodes prolongées et ce dans plus de 50% des cas (J. P. Buckley *et al.*, 2015a). De plus en plus d'attention aux dommages causés par le temps excessif passé assis est notamment rapportée par plusieurs journaux célèbres (The Globe and Mail, 2014) et articles scientifiques (O'keefe et Lavie, 2012) qui comparent « être assis » comme « the new smoking ».

En effet, de longues périodes assises, de façon régulière, ont été liées à un risque accru de maladies métaboliques telles que le diabète (Højbjerre *et al.*, 2010), l'obésité (Chau *et al.*, 2015; Levine et Miller, 2007), des accidents vasculaires cérébraux (Chau *et al.*, 2015) et d'autres maladies cardiaques (Chau *et al.*, 2015). Il a même été associé à un risque accru de décès prématuré (van der Ploeg *et al.*, 2012) et à un risque significativement plus élevé de mortalité de toutes causes (Chau *et al.*, 2015).

En plus des nombreux risques associés à la santé, la recherche suggère que passer trop de temps en position assis peut également affecter la performance au travail, augmenter le taux d'absentéisme, les accidents de travail et peut même avoir un impact sur les relations interpersonnelles de l'employé (Pronk *et al.*, 2004; Sliter et Yuan, 2015). Cela peut mener éventuellement à des coûts financiers importants pour les entreprises.

Il a donc été suggéré que des pauses régulières du travail assis pourraient aider à limiter ces risques (Thorp *et al.*, 2014). En effet, une réduction du temps assis est significativement corrélée avec divers bénéfices comme la diminution de douleurs du haut du dos et du cou, mais aussi une amélioration des états d'humeurs (Pronk *et al.*, 2012), une atténuation des inconforts musculo-squelettique (Pronk *et al.*, 2012) et une perte de poids (Roemmich, 2016). Là où les ordinateurs de bureau sont encore la norme, l'attention croissante aux effets négatifs des postes de travail traditionnels sur la santé fait en sorte que les organisations perçoivent les postes de travail actifs comme une solution potentielle aux dangers d'un trop grand temps passé assis (Owen *et al.* 2010).

Les postes de travail actifs sont spécifiquement conçus pour générer plus de demandes physiques qu'un poste de travail traditionnel assis, équipé d'une chaise et d'un bureau. Des exemples de stations de travail actives comprennent des bureaux intégrés à un tapis roulant, des bureaux debout assis, des bureaux avec un pédalier, ou encore des ballons d'exercice au d'utiliser lieu des chaises.

Bien qu'ils semblent apporter des bénéfices au niveau de la santé, on note une différence de performance en fonction de divers facteurs lors de l'utilisation de stations actives. Par exemple, Russel *et al.*, (2016) et Dutta, Walton et Pereira (2015) suggèrent que l'utilisation d'une station active n'est pas associée à une diminution de la performance ou de la perception de productivité vis-à-vis la tâche. Par ailleurs, Labonté-Lemoyne *et al.*, (2015) suggère une amélioration de la performance cognitive (l'attention et la mémoire du sujet) pour les utilisateurs utilisant un bureau intégré à un tapis roulant. Par conséquent, les postes de travail actifs peuvent être plus ou moins adaptés à certaines tâches (Straker, Levine et Campbell, 2009). Straker *et* al. (2009) propose que la performance d'une tâche quelconque puisse être liée à la fois à la demande physique (biomécanique) et à la demande cognitive (processus cognitif) pour la tâche.

Bref, aucun consensus n'est fait quant à l'impact des stations actives sur la performance des tâches informatiques (Torbeyns *et al.*, 2015), ce qui rend difficile pour les gestionnaires de prendre la décision d'adopter ce genre de poste de travail.

D'autre part, des recherches récentes basées sur des théories tirées de la kinésiologie font valoir qu'il est impératif que la recherche sur les systèmes d'information commence à prendre en compte la demande physique pour mieux comprendre le comportement, la perception, l'attitude et la performance des utilisateurs (Labonté-Lemoyne *et al.*, 2016; Ohlinger *et al.*, 2011b). Il y a deux types de demandes physiques en lien avec notre interaction avec la technologie, soit la demande physique directe et la demande physique indirecte. La demande physique directe se définit comme étant la quantité de mouvement requis pour l'utilisateur afin de contrôler et/ou interagir avec la technologie. En d'autres termes, le mouvement est initié de manière à atteindre son objectif final et comprend tous les mouvements nécessaires pour contrôler la technologie et d'interagir avec elle (Labonté-Lemoyne *et al.*, 2016). D'autre part, la demande physique indirecte avec la technologie est le positionnement physique et le mouvement du corps de l'utilisateur au cours de l'interaction avec la technologie (Labonté-Lemoyne *et al.*, 2016). Une demande physique plus élevée est identifiée comme étant de l'activité physique légère. Ce niveau d'activité physique a été identifié efficace pour améliorer le bien-être psychologique et réduire certains symptômes dépressifs (Sliter et Yuan, 2015 : 2).

Étant donné les enjeux relatifs à la santé et la performance des utilisateurs de technologies, il est essentiel pour les entreprises d'adopter des stratégies concernant ces problèmes (Pollack *et al.*, 2007). Ainsi, vu la possible implication de la demande physique lors de l'utilisation d'une station active (Botter *et al.*, 2016), une ouverture se crée afin d'éclaircir les variables pouvant influencer la performance dans une tâche TI.

1.2 Question de recherche

Peu de littérature fait référence à la demande physique directe et ses implications sur la performance d'une tâche. Dans un premier temps, nous voulons identifier le mouvement généré par une tâche spécifique, l'accent est donc mis vers la demande physique de l'interaction directe avec la technologie puisqu'il inclut tout le mouvement servant à contrôler et à interagir avec cette technologie (Labonté-Lemoyne *et al.,* 2016). Secondement, après avoir éclairci ce premier point, il sera possible de considérer les deux types de demandes physiques et leurs implications sur la performance. Ainsi, les questions de recherche se divisent de cette manière :

1. Article 1 : Dans quelle mesure les tâches quotidiennes de technologie de l'information (i.e., l'utilisation de la suite Microsoft Office 365) (Okta, 2015) ou encore l'utilisation d'outils mobiles (ex., tablettes et cellulaires) (Okta, 2015) implique la demande physique directe ?
    a. Quelle tâche TI génère le plus de demandes physiques directes et quelle tâche en génère le moins ?
2. Article 2 : En considérant également la demande physique directe et indirecte que génère une station active, quelles sont leurs implications sur la performance d'une tâche TI?

Cette dernière question permettra de déterminer entre autres le type de tâche (en fonction de la demande physique) qui devrait être compatible avec une station active dans le but d'apporter des recommandations quant à son utilisation.

1.3 Objectif de l'étude

L'objectif de ce mémoire est de permettre, dans un premier temps, d'avoir une meilleure compréhension de la demande physique directe générée par de diverses tâches relatives aux technologies de l'information effectuées en position debout et assise. Les tâches TI sont abordées comme ceux effectués à l'aide d'un appareil technologique (ordinateur, mobile) dans le cadre d'un travail de bureau.

Avec cette meilleure compréhension et par la détermination d'extrême de demande physique direct dans les tâches, l'objectif est de déterminer les implications du mouvement direct d'une tâche TI sur la performance de cette même tâche afin de pouvoir ajouter à la littérature des stations actives des recommandations quant à leurs usages en ayant évalué un construit impératif tel qu'est la demande physique. Cela permettra entre autres de déterminer quel type de tâche devrait être compatible avec les postes de travail actifs afin d'améliorer leur adoption, mais aussi d'améliorer le temps de mise en œuvre et rassurer les utilisateurs sur leur performance dans les tâches.

1.5 Contribution potentielle

Bien que les postes de travail actifs puissent avoir possiblement un impact sur la santé et la productivité de façon importante (Pronk et Kottke, 2009), la mise en œuvre de ces postes de travail et leur utilisation par les employés peuvent constituer un défi (Ben-Ner *et al.*, 2014). Ce mémoire permettra à des recherches subséquentes d'approfondir les connaissances reliées à l'impact de la station active sur la performance et les perceptions des utilisateurs. En ce sens, il permet une meilleure compréhension des facteurs à considérer lors de leur utilisation afin d'en retirer un maximum de bénéfices. En ce qui concerne les implications pour la pratique, dans un premier temps, déterminer quel type de tâche devrait être effectuée sur les postes de travail actifs pourrait améliorer l'adoption. Secondement, proposer et promouvoir des tâches spécifiques pourrait améliorer le temps de mise en œuvre et rassurer les utilisateurs sur leur performance dans les tâches. Troisièmement, étant donné qu'il n'y a pas de ratio défini quant au temps passé entre debout ou assis à un poste de travail actif (Karakolis et Callaghan, 2014) apporter des recommandations quant au type de tâche à effectuer permettrait de mieux gérer l'alternance entre la position assise et l'utilisation d'une station active.

1.6 Information sur les articles

1.6.1 Article 1

Une première version du premier article a été soumise à la conférence scientifique «Association des sciences administratives » en février 2017 dans le cadre du congrès de l'ASAC 2017. Cette association vise principalement à promouvoir la recherche, l'enseignement et la pratique dans le domaine des sciences administratives au Canada.

1.6.1.1 Résumé de l'article 1

Une meilleure compréhension de la demande physique (c'est-à-dire de la quantité et le type de mouvement requis par l'utilisateur pour contrôler et interagir avec la technologie) dans différents contextes d'utilisation devrait aider les chercheurs et les gestionnaires à identifier quelles tâches TI doivent être exécutées et dans quel contexte devrait-on faire l'utilisation des stations de bureaux actifs. Ainsi, l'objectif de cette recherche est d'explorer comment différentes tâches informatiques communes diffèrent en termes de demande physique lors de l'utilisation d'une station active. Une expérience intra-sujet a été réalisée en explorant la demande physique de deux positions d'utilisation, soit assise ou debout, selon 13 tâches TI communes. L'étendue du mouvement et l'activité musculaire des participants (n = 11) ont été enregistrées et comparées entre les postes et les tâches informatiques.

1.6.2 Article 2

Un second article considérant l'impact de la demande physique sur la performance a été soumis et accepté au « Sixteenth Annual Pre-ICIS HCI/MIS Research Workshop » à Séoul en Corée du Sud, une association pour les systèmes d'information ayant pour intérêt l'interaction humaine-ordinateur.

1.6.2.1 Résumé de l'article 2

En se basant sur la littérature des systèmes d'information et de la kinésiologie, nous proposons et testons empiriquement un modèle de recherche afin d'évaluer quelles tâches informatiques sont les plus adaptées à une station active. À l'aide d'un design expérimental intra-sujet, une expérience impliquant 40 participants a été effectuée. Étant donné que les résultats de la recherche sur les effets des postes de travail actifs sur la performance des utilisateurs ne sont pas concluants, nous soutenons que la demande physique et la difficulté des tâches jouent un rôle dans l'influence de la performance et des perceptions des utilisateurs de technologies lors de leur utilisation de postes de travail actifs. Une expérience manipulant le niveau de la difficulté des tâches ainsi que les physiques directes et indirectes ont été effectuées. Les résultats suggèrent que la difficulté des tâches modère les relations entre les perceptions et la performance des utilisateurs et la demande physique directe et indirecte. Les résultats aideront les organisations et les employés à choisir la bonne tâche quand il s'agit d'utiliser des postes de travail actifs.

1.7 Contributions personnelles

La réalisation des articles de ce mémoire s’est effectuée dans le cadre d’expériences au Tech3lab. Afin d’assurer la compréhension de ma contribution dans les processus de rédaction, le tableau suivant représente ma contribution pour chaque étape du processus de recherche. Ma contribution est indiquée en pourcentage.

Tableau 1 : Contributions et responsabilités dans la rédaction des articles

Étape	Contribution et tâches effectuées
Revue de la littérature	Effectuer une revue de la littérature afin d’identifier la problématique reliée à notre relation avec les technologies et identifier « le gap » au niveau de la performance en contexte d’utilisation de la station active – 100% Élaboration d’un modèle de recherche déterminant les variables pertinentes à mesurer lors des collectes de données – 80% • Aide à la détermination de mesures et de stimuli qui devait être utilisée lors de l’expérience • L’équipe de recherche a fourni des pistes de recherches et quelques articles pertinents à l’élaboration du modèle.
Conception du design expérimental	Création des formulaires nécessaires pour le CER – 80% Aide à la mise en place de la salle de collecte – 60% • L’équipe s’est assuré de placer les instruments de mesure plus complexes Cycle de prétest afin d’assurer la validité du protocole – 50% • J’ai rapporté les changements nécessaires afin d’assurer le bon déroulement de l’expérience (ajustement des tâches), ajustement des stimuli, temps, etc. L’équipe a aidé avec le côté plus technique et apporté les ajustements nécessaires à ce niveau.

Recrutement des participants	**Article 1 :** Recrutement sous forme de convenance – 100% Gestion des horaires en fonction des participants sur place -100% **Article 2 :** Création du formulaire de sollicitation publié sur la plateforme de recrutement– 100% S'assurer de la présence d'un participant pour chaque plage de collecte -100%: • Contact des participants par courriel et téléphone • Confirmation des critères de participation • Programmer/gérer les horaires des participants Conception du cartable d'expérimentation pour assurer le suivi des participants et le bon déroulement de l'expérience – 100% Responsable des compensations – 100%
Prétests et collecte	**Article 1 :** Responsable de la collecte - 100% • Donner les indications aux participants • Poser les instruments de mesure • Synchronisation entre les logicielles d'enregistrement de données **Article 2 :** Responsable des opérations lors des collectes – 50% • L'équipe s'occupait de la pose des instruments et de donner les indications au participant lors de l'expérience. Assurer ma disponibilité en cas de problème afin d'effectuer une assistance technique dans le cas de problèmes lors de la collecte – 100%
Extraction et transformation des données	**Article 1 :** Détermination des mesures utiliser lors de l'analyse nécessaire à l'extraction – 80% Extraction des données – 50%

<table>
<tr><td></td><td>Un membre de l’équipe est intervenu afin d’extraire les données sur le logiciel MATLAB et de créer les graphiques d’analyses appropriés. Article 2 : Extraction et mise en forme des données psychométriques pour des fins d’analyse statistique – 100% </td></tr>
<tr><td>Analyse des données</td><td> Article 1 : Interprétation des données basée sur de graphiques ANOVA – 100% Article 2 : Détermination de la méthodologie des calculs de performance des participants – 90% Analyse statistiques, participation active dans les analyses afin d’assurer la réalisation des objectifs - 75% Aide pour tests statistiques complexes, statistiques descriptives, vulgarisation des résultats via SPSS</td></tr>
<tr><td>Rédaction</td><td> Écriture de deux articles scientifiques 100% Des commentaires ont été faits de la part de tous les auteurs des articles tout au long de la rédaction afin d’assurer l’amélioration continue des articles.</td></tr>
</table>

CHAPITRE 2: LES ARTICLES

2.1 Article 1

An exploratory quantitative investigation of physical demand in everyday information technology usage

Marc-Antoine Jutras <MSc Student>
HEC Montréal
3000, chemin de la Côte-Sainte-Catherine
Montréal (Québec) Canada H3T 2A7

Elise Labonté-Lemoyne
HEC Montréal
3000, chemin de la Côte-Sainte-Catherine
Montréal (Québec) Canada H3T 2A7

Pierre-Majorique Léger
HEC Montréal
3000, chemin de la Côte-Sainte-Catherine
Montréal (Québec) Canada H3T 2A7

Sylvain Sénécal
HEC Montréal
3000, chemin de la Côte-Sainte-Catherine
Montréal (Québec) Canada H3T 2A7

Marie-Eve Mathieu
Département de kinésiologie de l'Université de Montréal
CEPSUM, 2100, boul. Édouard-Montpetit
Montréal (Québec) Canada H3C 3J7

Mickael Begon
Laboratoire de simulation et de modélisation du mouvement, Département de kinésiologie de l'Université de Montréal
1700, rue Jacques Tétreault
Laval (Québec) Canada H7N 0B6

ABSTRACT

Nowadays, information technology (IT) users can perform tasks using devices ranging from desktop computers to mobile phones while being seated or in movement. A better understanding of the physical demand (i.e., quantity and type of movement required from the user to control and interact with the technology) in different usage contexts should help researchers and managers in identifying which IT tasks should be performed in which usage context. Thus, the objective of this research was to explore how various common IT tasks differ in terms of physical demand. A within-subject experiment was performed exploring the physical demand of two usage positions (seated or standing) and 13 common IT tasks. Participants' (n=11) range of motion and muscle activity were recorded and compared across positions and IT tasks.

1. INTRODUCTION

In this paper, we investigate the extent to which daily information technology tasks involve physical demand. Understanding the physical demand required to interact with IT is becoming increasingly important because technology interactions have rapidly evolved over the past few years. The use of active workstations in office environments (i.e., a desk where the user can stand and even walk while working) is one such case that generates more physical demand than simply sitting in front of a computer. Recent research argues that it is imperative for information system (IS) research to start taking physical demand into account to better understand users' behavior, perception, attitude, and performance (Elise Labonte-LeMoyne *et al.*, 2016).

In this exploratory study, we investigate the physicality (i.e., physical demand) of interaction with technology. In other words, we measure the physical amplitude of movement and muscular activity involved in daily IT tasks performed in an office environment equipped with an active workstation. Leveraging methods and tools used in the field of kinesiology (i.e., the science of human movement), we use the Plug-in Gait model (Vicon Motion Systems, Oxford, UK) and electromyography to explore five dimensions of direct physicality of 13 daily IT office tasks. In doing so, our objective is to inform information systems research in order to provide IS researchers an objective measure of physical demand for a representative set of IT tasks.

2. LITERATURE REVIEW

2.1 Usage and impact of active workstations

It has been demonstrated that prolonged sitting time and sedentary behavior has emerged as a risk factor for various negative health outcomes. Indeed, long periods of sitting, on a regular basis, has been linked to an increased risk of metabolic illnesses such as diabetes (Højbjerre et al. 2010), obesity (Levine & Miller, 2007), stroke (Chau et al., 2015), other heart disease (Chau et al., 2015), and heart failure (Chau et al., 2015). It has even been linked to an increased risk of all cause mortality (Van der Ploeg et al. 2012). Research suggests that regular breaks from seated work could help limit those risks (Thorp, Kingwell, Owen, & Dunstan, 2014) as a reduction in sitting time is significantly correlated with improved outcomes such as reduced upper back and neck pain as well as fewer mood states (Pronk, Katz, Lowry, & Payfer, 2012).

Active workstations are workstations specifically designed to generate more physical demand than a traditional seated workstation, equipped with a chair. Examples of active workstations include treadmill desks, standing desks, cycling desks, or exercise balls instead of chairs. Because of increased attention on the negative health effects of traditional workstations, organizations perceive active workstations as a potential solution to the dangers inherent in spending too much time in a seated position (Alkhajah et al., 2012).

Active workstations are adopted with the objective of enhancing employees' health such as attenuated musculoskeletal discomfort (Pronk et al., 2012) and a higher energy expenditure possibly leading to weight loss (Roemmich, 2016). Research suggests that the use of active workstations does lead to an increase in the level of physical activity, heart rate, and energy expenditure (Botter et al., 2016) without added discomfort (Gibbs, Kowalsky, Perdomo, Grier, & Jakicic, 2016). To our knowledge, however, no study has evaluated those physical demands across a variety of daily IT tasks involving different levels of amplitude and muscular activity.

2. 2 Physicality: indirect and direct

To properly evaluate the physical demand of a specific task, we must first define what this physical demand consists of. Previous studies (Elise Labonte-LeMoyne *et al.*, 2016) based on kinesiology theories have been mobilized to measure the impact of physicality on variables and constructs of interest to IS researchers. Physical demand can be *defined* as the physicality of direct and indirect interaction with technology. On the one hand, the physicality of direct interaction with technology is the *"quantity and type of movement required from the user to control and interact with the technology*" (Elise Labonte-LeMoyne *et al.*, 2016). In other words, the movement is being initiated in such a way as to accomplish its end goal. The movement is planned and readjusted according to its sensory feedback. Basically, the physicality of direct interaction includes all the movements necessary to control the technology and interact with it, along with its sensory feedback (Elise Labonte-LeMoyne *et al.*, 2016). On the other hand, the physicality of indirect interaction with technology is the "*physical positioning and movement of the user's body during the interaction with technology including that which is necessary to support the device"* (Elise Labonte-LeMoyne *et al.*, 2016). For example, walking on a treadmill (while performing an IT task) would be considered an indirect physical interaction. The scope of this exploratory study will be limited to the physicality of direct interaction.

2.3 Dimensionality of direct physical interaction

Building upon direct physicality literature, we propose five dimensions to explore the direct physical interaction. Each takes into account a portion of the movement required to control the technology and interact with it.

1- Information acquisition: Neck rotation is an essential component of the information acquisition action since it might require the participant to visually search for the information, to type/handwrite the information, or to use a device (Straker, Pollock, Burgess-Limerick, Skoss, & Coleman, 2008).

2- Workspace: In this dimension, we want to evaluate the three-dimensional displacement of the hand in the environment. When performing a task, we usually use multiple input devices around us and those movements are needed to complete the task.

3- Gross and fine motion interactions: For comparison purposes, to determine whether a task demands shoulder and arm muscle activations for large/gross motions (Kothiyala & Kayisb, 2000) or forearm muscle activation for fine motion of the wrist and fingers (Meulenbroek, Van Galen, Hulstijn, Hulstijn, & Bloemsaat, 2005).

4- Posture during interaction: The back and scapula muscle may be activated to maintain the posture or perform certain tasks, such as using a touchscreen or to read closer on the screen (Schüldt, Ekholm, Harms-Ringdahl, Arborelius, & Németh, 1987).

5- Velocity of the interaction: The three-dimensional velocity of the hand at which the movement is performed. This is indicative of the speed at which the interaction is performed by a given user (Yoon, Soh, Bae, & Seung Yang, 2001).

3. METHOD

A laboratory experiment was conducted to evaluate the amplitude of movement and muscular activity associated with 13 IT office tasks in an active workstation context. A sit-stand active workstation was used for the experiment. Thus, a 2 (seated or standing) X13 (IT tasks) within-subject design was used. The experiment was conducted at our institution, in a specialized biomechanics lab.

3.1 Participants

Data was collected from 11 healthy participants (45.5% female). The participants' body mass index (BMI) was calculated to characterize the population evaluated. A BMI between 18.5 and 24.9 is associated with a healthy weight, while a BMI between 25 and 29.9 is associated with being overweight. The mean of the 11 participants is 22.1. 90.9% of them had a BMI in the range of healthy weight (Table 2).

Tableau 2:Participants' body characteristics

	Mass (kg)	**Height** (m)	**BMI** (kg/m^2)
Mean	66.5	1.73	22.1
Standard deviation	11.8	0.11	2.9

3.2 IT tasks

Building upon recent industry reports of IT usage in work context (Gartner, 2015; Okta, 2015), we developed a list of 13 IT tasks carried out by office workers, on a daily basis (Table 3). To ensure the homogeneity of the business context, we adapted all the tasks to business tasks with the Microsoft (MS) Office Suite. Finally, a scenario was prepared for each task in order to provide a business context. Table 3 presents each task and scenario and the order in which the participants performed them.

Tableau 3: IT tasks and scenarios

IT Tasks [Abbreviation]	Scenario
1. Type [TypeFree]	Using MS Word, type freely a summary of your work day.
2. Type a dictated message [TypeDictated]	Using MS Word, type what the experimenter dictates.
3. Type by looking at a sheet on the desktop (neck movement) [TypePrintedTxt]	Using MS Word, transcribe a text from a printed sheet laid flat on the desk.
4. On-screen playback [Reading]	Reading text on screen using MSWord.
5. Type and use the numeric keypad [Excel]	Using MS Excel, type and use the numeric keypad to make a schedule (i.e., writing work schedule, days and hours).
6. Using the mouse [Mouse]	Using MS Visio, modify the shape of a diagram using only the mouse.
7. Mouse-Key Combination [Mouse-Key]	Using MS Outlook, type and send an email using the mouse and the keyboard.
8. Video conference [Skype]	Using MS Skype, take a call and interact during the video conference.
9. Using the phone at the same time as the computer [PhoneType]	Take a phone call and take notes using MS Word during the conversation.
10. Using a trackpad [Trackpad]	Using MS Visio, modify the shape of a diagram using a trackpad (with a pen).
11. Using the mouse [Scroll]	Find a specific page in a document by scrolling down.

12. Handwriting [Handwriting]	Handwrite your afternoon plans on a piece of paper.
13. Using a Touch Screen [Touchscreen]	Using MS Outlook, send an email using only the touchscreen.

3.3 Instrumentation and measures

Two types of measures were used to assess the participants' physicality while performing the 13 IT tasks, either sitting or standing. As shown in Figure 1, the range of motion (i.e., the angle of the extension of the movement) was measured by the Plug-in Gait model (Vicon; Oxford UK), while the electrical activity of the muscles during rest and contraction was measured using an electromyogram (EMG), which also helped to observe patterns around the movement. In addition, sports clothing was needed to ensure that the EMG data could be captured and that the clothes did not interfere with the sensors.

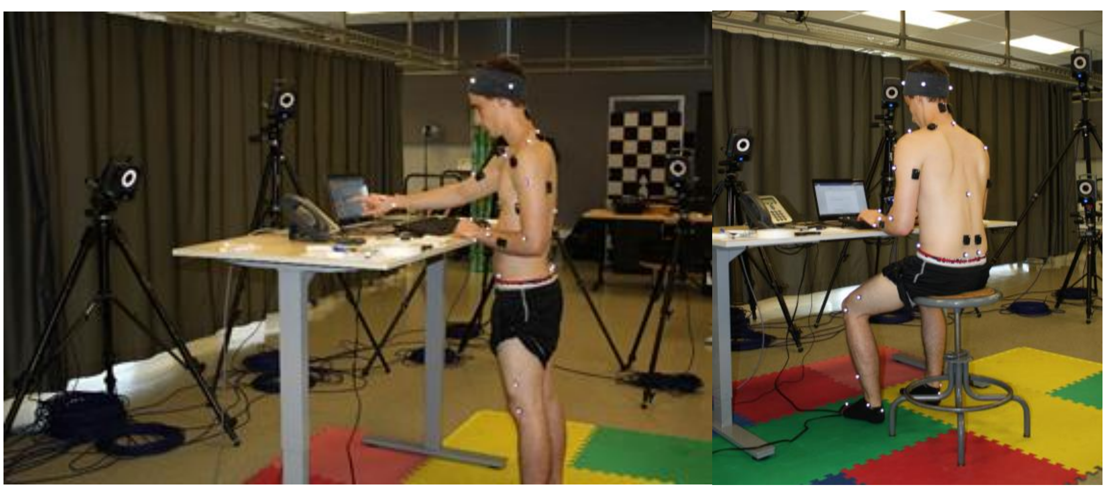

Figure 1: Experimental setup with reflective markers, EMG sensors applied on the skin of the participant in interaction with an active or seated desk

The Vicon Plug-in Gait model consists of 47 reflective markers positioned on bony landmarks to define body segments. Eighteen calibrated cameras were placed at different angles to measure motion in real-time (Figure 2). The cameras measured the position of the reflective markers worn by the participant. Based on these positions, the Nexus software was used to calculate the body segment kinematics (i.e., movement), including joint angles (flexion, abduction, and rotation) and translations (forward-backward, left-right, and upward-downward). Fourteen surface EMG electrodes were positioned on the subject. The positioning was done according to the locations that can be activated during an office task: cervical, lumbar, trapezius, anterior deltoids, triceps, biceps and forearm, both on the left and right sides. The Delsys software was used to capture EMG data. All the data processing, including EMG filters application, envelop determination, and normalization (with respect to the average signal) was performed in MATLAB (Mathworks, Massachusetts, USA).

Amongst several variables based on the Plug-in Gait kinematic model and the EMGs, six variables were retained to represent categories presented in section 2.3, namely: neck rotation, EMG muscles activation of the forearm, EMG muscles activation of the arm, EMG back muscle activation (lumbars), hand displacement and hand velocity. Charts representing the different variables and their category were generated for the analysis.

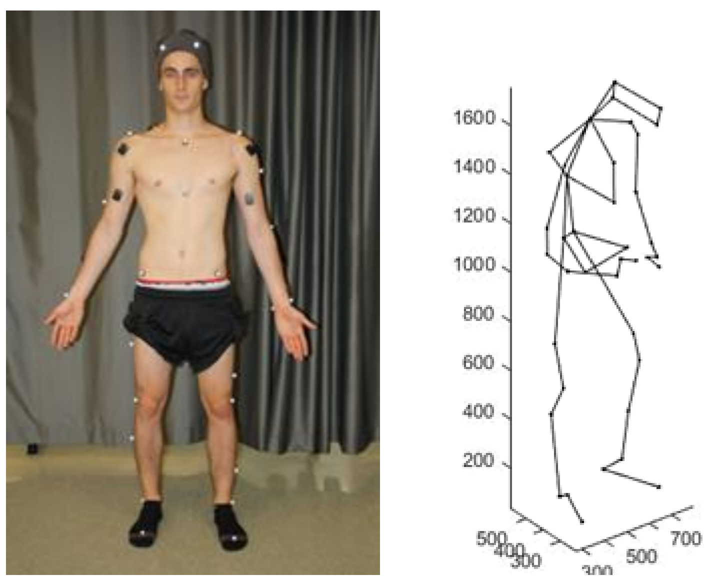

Figure 2: Sensors and markers set up (left) and representation of the kinematic modelling of the Plug-in Gait model (right)

3.4 Procedure

Recording time for each task was approximately 20 seconds or 1 hour and 15 minutes per participant, for the entire experiment. Each participant first performed 13 tasks in a standing position, and then in a sitting position. Participants adjusted the desk, either in the standing or sitting position, to a comfortable height. They started in a neutral position then performed the task and went back to a neutral position. The neutral position refers to a steady position without moving, either standing or sitting, front arms on the desk and upper body straight. We recorded the movement from both neutral positions to isolate the movement generated by the task.

4. RESULTS

Since most participants were right-handed and the direct physical demand is related to the controlled movement to perform the task, we mainly used the data on the participant's' right side. Results are presented according to the five proposed dimensions in the literature review: Information acquisition, Workspace, Motion amplitude, Posture, and Velocity. Moreover, for each dimension, two representative measures are plotted.

4.1 Information acquisition

Rotating the neck is an essential component of the action associated with acquiring information, since it may require the participant to look at different areas on the desk in order to gather the necessary information. As shown in figure 3, the EMG of the forearm is also solicited, because acquiring information requires either using the keyboard or writing down the information, both of which activate the forearm muscles. The seated position generally generates more rotation of the neck, which may involve a smaller overall view of the working surface, since the user has to go and obtain the information around him by looking left and right. This is even more true when the person in a sitting position needs to look to the side to check the printed document for purposes of transcribing information [TypePrintedTxt]. It also applies to the [PhoneType] task, where the participant has to reach the phone then look back to his computer screen. The implications for the neck are similar in a task involving the interaction between the numeric pad [Excel] and the keyboard, since the participants had to look at both to situate their hand movement. Since [Mouse-Key] generates much less rotation of the neck, we can observe that it is much more intuitive to use the mouse in combination with the keyboard so there is no need to watch what we do with it. According to the same logic, the participants were far less familiar with the trackpad, which generated much more rotation of the neck in a seated position. In a seated position, it appears that the use of a less common device generates more neck rotation.

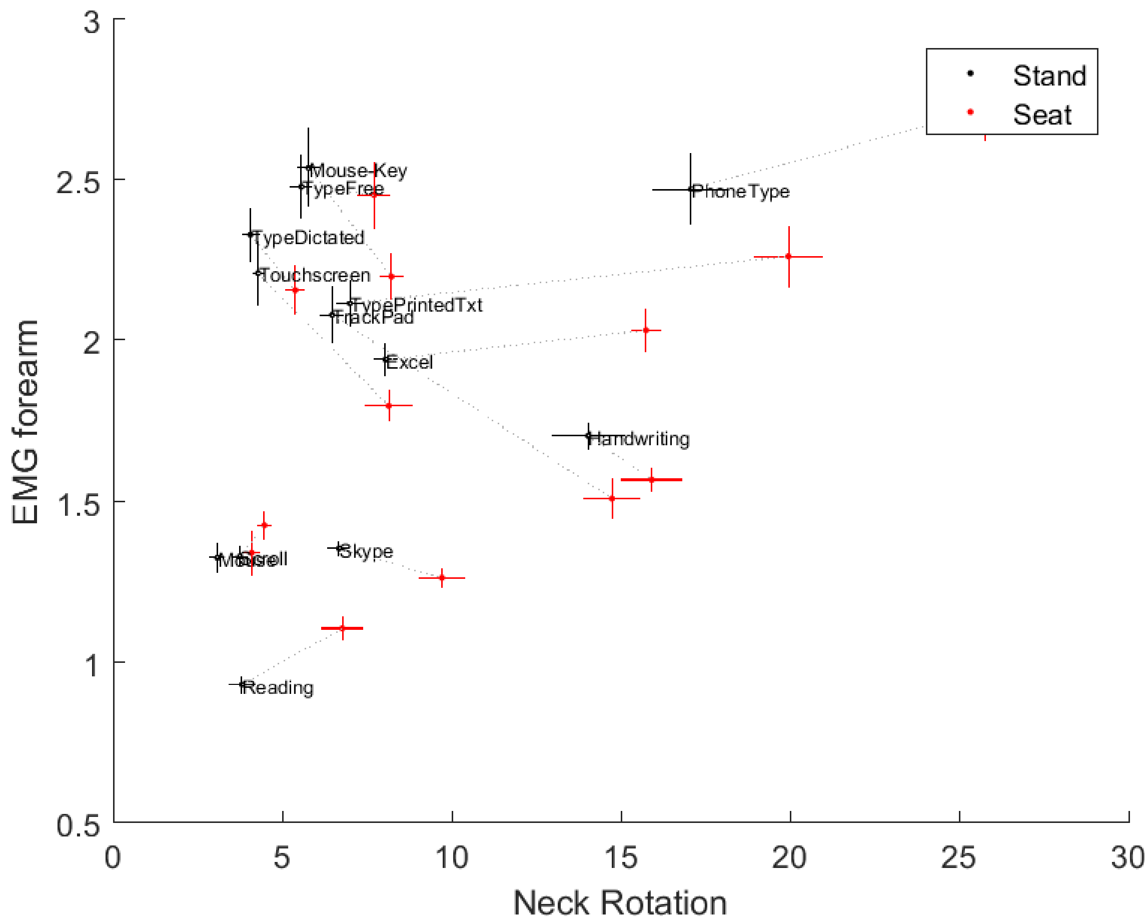

Figure 3: Neck rotation in degrees *versus* forearm electromyography involved in 13 IT tasks and two positions (mean and standard error of the mean)

Note : Mean and standard error of the mean are illustrated by the size of the cross. To facilitate the comparison between positions, standing and sitting conditions for a given IT task are linked via a dotted line.

On closer scrutiny, EMG data of the right forearm shows that typing tasks demand more activation. Forearm activation is needed to perform typing tasks as well as the [Touchscreen] task requiring on-screen typing. The [Handwriting] task that is equivalent to typing, for taking information, is also slightly below the typing tasks. The results are similar, but the level of forearm activation is lower. As an equivalent to typing, the [Handwriting] task is less demanding in terms of activation, but generally entails a higher level of neck rotation. A similar conclusion can be reached, in the seated position, for the [Trackpad] task that basically required the use of a pen, like the [Handwriting] task. Overall, the [PhoneType] and [Reading] tasks, either in a seated position or a standing position, entail the most direct physical movement along the two axes, in the action of giving information.

4.2 Workspace

The right-hand displacement was used to evaluate the interaction with the work environment. A displacement consists of a change in hand position. The activation of the forearm muscles (EMG) was also used. Interaction with the environment consists of taking an object around us, moving and using different devices, which justify the forearm activation and the displacement. We can observe that there is less displacement of the right hand while sitting, except for the [Handwriting] task, where the standing person had to take a position to be comfortable, with the placement of the sheet of paper that was, in most instances, located beside the participant (the sheet was placed by the participant). This may suggest the person would use a broader space on the desk while standing. The [Handwriting] and [Trackpad] tasks generate more hand displacement than most of the keyboarding tasks. Most of the keyboarding tasks suggest a steady hand on the keyboard, where the fingers were doing most of the work, even where the hands navigated across the keyboard, except for the [PhoneType] and [TypePrintedTxt] tasks, which required that the subject move to the phone and make a general movement toward the sheet to copy the printed text. The [Handwriting] task solicits much more of the whole hand.

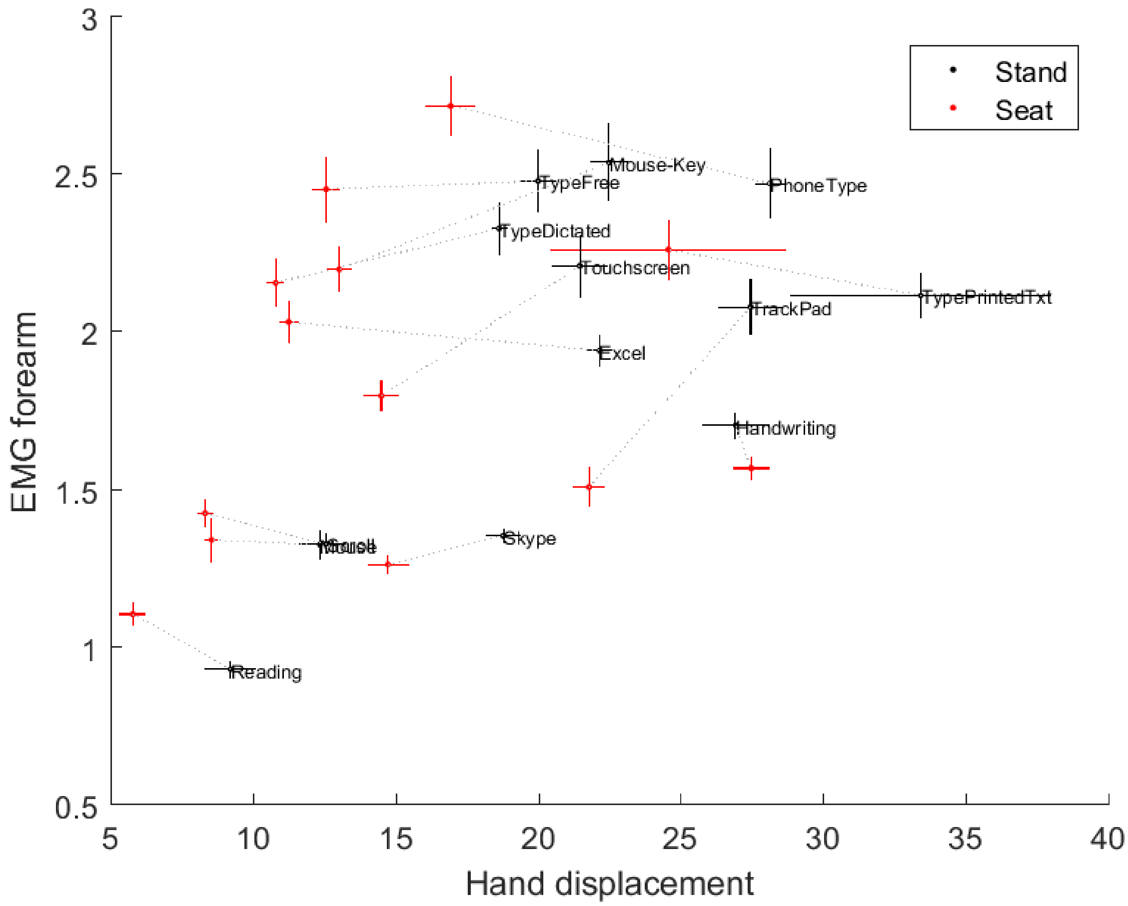

Figure 4: Hand displacement *versus* forearm electromyography involved in IT tasks

Overall, the tasks that generate the most interaction with the environment, either for the EMG activation and hand displacement, are those that require the keyboard due to their implication for the EMG (over the [Handwriting] task). The [TypePrintedTxt] task would be the one that involves a higher level of interaction with the environment in a sitting and a standing position, which is consistent with the person moving toward the sheet and then putting his hands back toward the keyboard, generating activation in the forearm. The lowest level of interaction with the environment would obviously be the [Reading] task.

4.3 Gross and fine motion interactions

Gross motion (EMG forearm) involves movement within a relatively large space where fine motion (EMG forearm) relates more to small and precise movement. By comparing both, we can observe if a task implies a larger movement or greater precision. Obviously, we can see that the [Touchscreen] task involves a considerable amount of large motion, in both sitting and standing positions. Otherwise, there are two groups: the first barely generates any motion, such as on the [Skype], [Scroll], [Mouse], [Reading] tasks, while the second involves the keyboard. Keyboarding tasks are related to more precise movement. In terms of small motion, the [PhoneType] task stands out the most in sitting and standing positions. In terms of gross motion, the [Touchscreen] task stands out. Either in sitting or standing position, the [Reading] and [Scrolling] tasks basically do not generate a lot of motion at the forearm level.

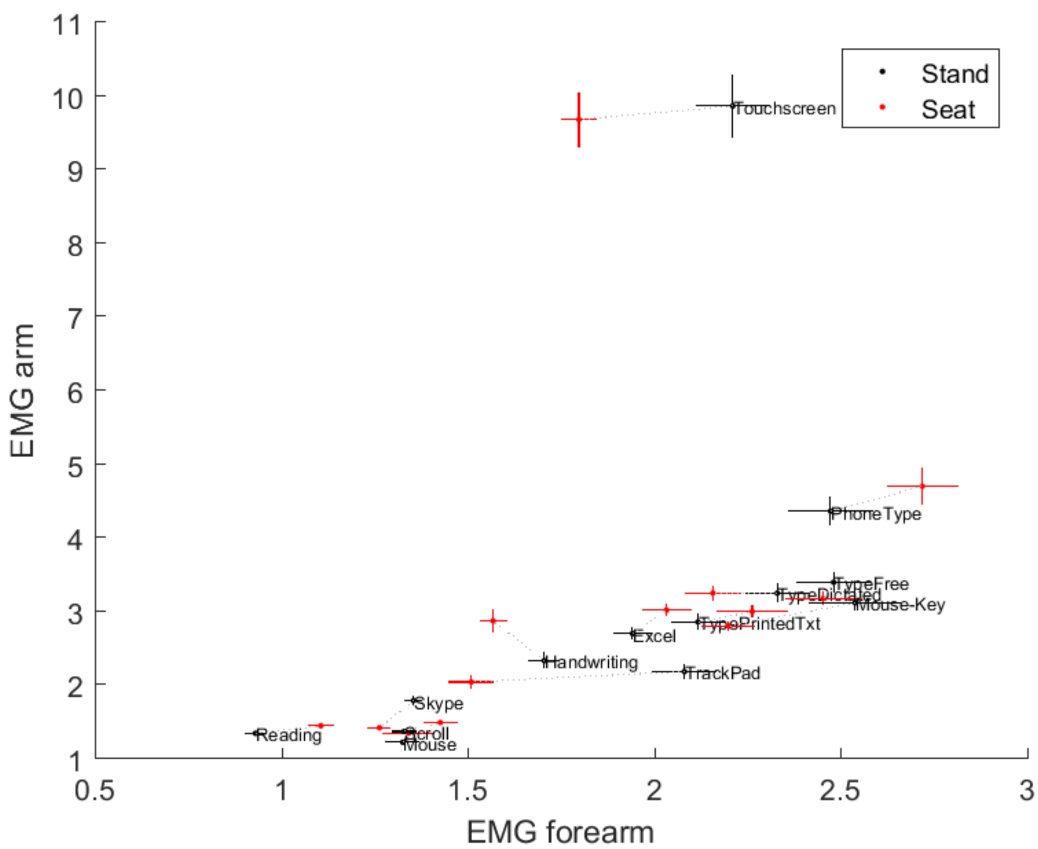

Figure 5: Arm and forearm movements in IT tasks

4.4 Posture

Neck rotation and lower back EMG muscle activation were observed to gain an overall impression of the implications for the back in tasks. In all cases, there is more rotation and EMG muscle activation for the back while seated. Significantly, the lumbar muscles are strongly activated in active position, which is consistent with the literature in the sense that discomforts can occur over time with time spent in a sitting position. There is little overall variation in standing position, except for the [Handwriting], [Touchscreen] and [PhoneType] tasks, where the performance is quite different (usage of different devices, not only mouse/trackpad and keyboard). The [PhoneType] task stands out mainly for the neck rotation. The [Touchscreen] task for the lower back EMG is much higher than the other tasks and may be due to the need to lean forward, where the lower back has to support more weight (i.e., to support the arm that stretches to tap on the screen). Combining the two axes, we would suggest that the [PhoneType] task generates a higher level of postural involvement in both the standing and sitting positions, but the higher level of lumbar muscle activation generated by the [Touchscreen] tasks should also be closely considered. The [Reading] task would have the least postural involvement in a standing position and arguably the least in a sitting position (with the [TypeDictated] task).

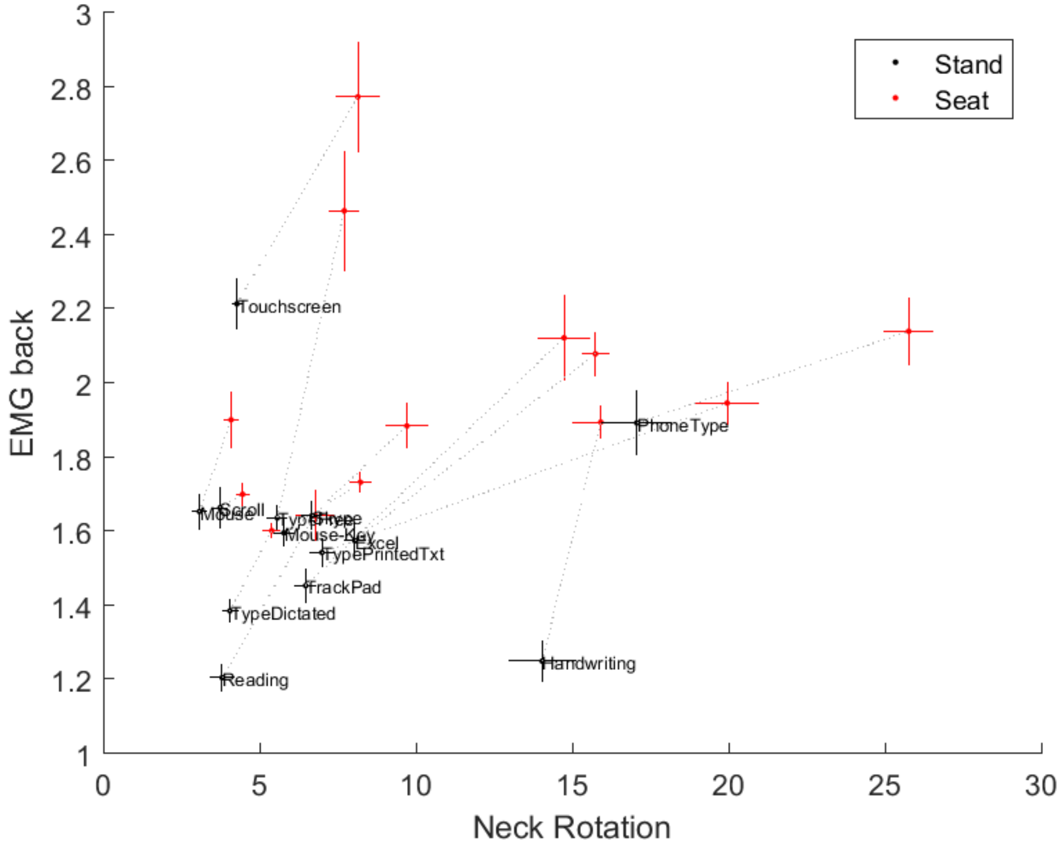

Figure 6: Neck rotation and back movement in IT tasks

4.5 Velocity

The velocity of the task can be evaluated with the speed of the movement. The velocity is the translational speed expressed by the reference of the segment. Hand displacement and its velocity are measured to identify the two extremes of tasks in terms of effectiveness. There is clearly less displacement of the hand in the seated position and slightly lower at the speed of movement of the hand, except for two tasks we are accustomed to performing: [Mouse] and [TypeFree]. In terms of velocity, [Mouse-Key] has the higher value in sitting and standing positions. This is consistent with our everyday uses of those two elements combined. The [Reading] task has the lowest velocity in both standing and sitting positions. This doesn’t mean that the subject did not perform its task, but that his movement was at its slowest in this specific task. On the other hand, the [PhoneType] task seems to generate the most effectiveness in the movement in a standing position. In the seated position, [Mouse-Key] for velocity and [Handwriting] for displacement are the ones that stand out for the most movement.

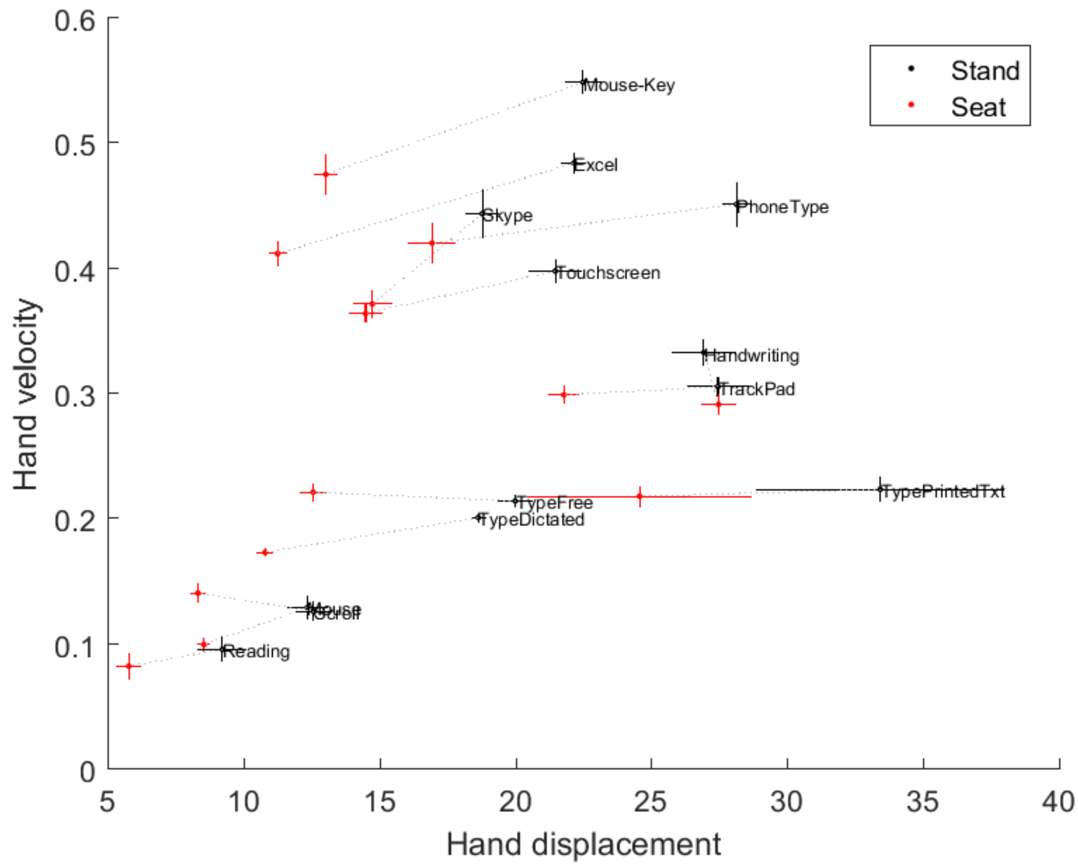

Figure 7: Hand displacement and hand velocity in IT tasks

5. DISCUSSION

In this study, we analyzed one of the independent variables of performance, direct physicality demand. A sit-stand workstation was the object of evaluation. By experimenting different desk job tasks, we will take the tasks at both extremes to test the effects of the interaction of direct movement on the performance of work tasks. Since each task generates a large amount of motion, we will globally identify each maximum and minimum in sitting and standing positions, according to each category identified in the analysis.

5. 1 Most direct physicality in a standing position

In the "Information acquisition" category, the [PhoneType] task generated the most movement. In the "Workplace interaction" category, [TypePrintedTxt] had the highest value for hand displacement and [PhoneType] generated more muscle activation for the EMG. Arguably, the [Phone Type] task also entails considerable "Postural" movement in relation to both axes (Lumbar EMG and neck rotation), but it is essential to mention the [Touchscreen] task for its distinctive EMG muscle activation, which is higher by a large margin than it is for all the other tasks. It is clear that the [Touchscreen] task generated the most direct physical interaction in the "Gross motion" category. For the "Small motion" category, on the other hand, there is a close battle between [PhoneType], [Mouse-Key] and [Type Free]. By combining the two axes in the "Velocity" category, we can consider the [PhoneType] task for the most interaction, but looking at right hand speed alone, the [Mouse-Key] task is distinctive.

For standing tasks, we can conclude that the [PhoneType] task entails the most direct physical involvement, since it appears in the majority of categories. As well, we should not neglect the [Touchscreen] task for its greater and distinctive direct physicality in two categories.

5.2 Most direct physicality in a sitting position

Similar to the standing position, the [PhoneType] task in the "Information acquisition" category generated the most movement. In the "Workplace interaction" category, the considerable amount of hand displacement in the [Handwriting] task bears mentioning. Perhaps, [TypePrintedTxt] follows closely and has larger implications for EMG muscle forearm activation, thus making it the task with the greater physicality in this category. The [Touchscreen] task has fairly important lower back implications, but [Phone Type], again, involves more neck rotation. Compared to [Touchscreen], the [PhoneType] task has quite a small amount of EMG activation for the lumbars, but [Touchscreen] had a great difference in sitting position compared to the other tasks. In the "Posture" category, for that matter, [Touchscreen] is the task that demands the greatest physicality. As in the standing position, the [Touchscreen] task has the most involvement in terms of "Gross motion" and again, [PhoneType] has the greatest involvement in terms of "Small motion". In the "Velocity" category, the [Mouse-Key] task is selected, and [Handwriting] for displacement. Where there are a lot of implications for [PhoneType] and [Touchscreen] (for larger movement), the conclusions would be fairly similar. In this case, since the [Touchscreen] task has the larger involvement in the postural analysis.

5.3 Least direct physicality in a standing position and sitting position

If we divide the categories, each has [Reading] as the lowest in the standing position. The only one that would be disputable is "Gross motion", where [Mouse] and [Scroll] tasks both have low muscle EMG arm activation, such as in the [Reading] task. In a sitting position, the conclusions are the same, except for the "Posture" category, where the [TypeDictated] task has the lowest physicality. The least direct physicality would be the [Reading] task, in sitting and standing positions. In general, we would consider that the task associated with the least direct physical interaction is [Reading] while the one associated with the most direct physical interaction is [Phone Type] closely followed by [Touchscreen].

6. CONTRIBUTIONS AND CONCLUSION

To our knowledge, the direct physical demand of IT tasks had not been empirically investigated to date. Our results suggest that physical demand varies greatly between various IT tasks. For instance, we observed that performing a touch screen-based task involves very different movements (gross motion) than most of the IT tasks investigated. Thus, this research constitutes a step forward in identifying which type of IT tasks are the most appropriate when using an active workstation. Future research could use our findings to investigate specific IT tasks (in sitting or standing position) that represent the extremes in terms of direct physicality.

Although active workstations can have important health and productivity (Pronk & Kottke, 2009), implementing these workstations and having employees use them can be a challenge (Ben-Ner, Hamann, Koepp, Manohar, & Levine, 2014). Furthermore, long-term adoption may require regular promotion and reinforcement initiatives (Mackey et al., 2015). Knowing which type of task should be performed on active workstations could improve adoption. Suggesting and promoting specific tasks could improve implementation time and reassure users about their performance in tasks. Since there is no general agreed-upon usage ratios for time spent between standing and sitting at workstations, it could also generate recommendations on ratios knowledge (Karakolis & Callaghan, 2014), where a better understanding of the usage of an active workstation could lead to optimized sit-stand work alternation.

As with any studies, this research has limitations. First, task and participant position were not randomized, resulting in the possibility of carry-over effects. Participants were mainly health-conscious, physically active and generally healthy. For time consideration, tasks only lasted 20 seconds each. Finally, we used the standing workstation as representative of an active workstation. Our objective was to contribute to the literature by exploring the physicality of various IT tasks. Our results suggest that tasks do place different physical demand on users. Ultimately, these findings should help researchers and managers determine which tasks are better suited for active workstations.

References

Alkhajah, T. A., Reeves, M. M., Eakin, E. G., Winkler, E. A. H., Owen, N., & Healy, G. N. (2012). Sit-stand workstations: A pilot intervention to reduce office sitting time. *American journal of preventive medicine, 43*(3), 298-303.

Ben-Ner, A., Hamann, D. J., Koepp, G., Manohar, C. U., & Levine, J. (2014). Treadmill workstations: The effects of walking while working on physical activity and work performance. *PLoS ONE, 9 (2) (no pagination)*(e88620). doi:http://dx.doi.org/10.1371/journal.pone.0088620

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

Chau, J. Y., Grunseit, A., Midthjell, K., Holmen, J., Holmen, T. L., Bauman, A. E., & Van der Ploeg, H. P. (2015). Sedentary behaviour and risk of mortality from all-causes and cardiometabolic diseases in adults: evidence from the HUNT3 population cohort. *Br J Sports Med, 49*(11), 737-742. doi:10.1136/bjsports-2012-091974

Gibbs, B. B., Kowalsky, R. J., Perdomo, S. J., Grier, M., & Jakicic, J. M. (2016). Energy expenditure of deskwork when sitting, standing or alternating positions. *Occup Med (Lond)*. doi:10.1093/occmed/kqw115

Højbjerre, L., Sonne, M. P., Alibegovic, A. C., Dela, F., Vaag, A., Meldgaard, J. B., et al. (2010). Impact of physical inactivity on subcutaneous adipose tissue metabolism in healthy young male offspring of patients with type 2 diabetes. Diabetes, 59(11), 2790–2798. http://dx.doi.org/10.2337/db10-0320.

Kothiyala, K., Kayisb, B. (2001). Workplace layout for seated manual handling tasks: an electromyography study, *International Journal of Industrial Ergonomics, 27,* 19-32

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

Labonte-LeMoyne, E., Leger, P-M., Senecal, S., Santhanam, R. (2016) Physical interaction with technology: kinesiology as a reference discipline for information systems research, *International Conference on Information Systems 2016, 01.* Conference Theme Track: Digital Innovation at the Crossroads

Levine, J. A., & Miller, J. M. (2007). The energy expenditure of using a "walk-and-work" desk for office workers with obesity. *British Journal of Sports Medicine, 41*(9), 558-561. doi:http://dx.doi.org/10.1136/bjsm.2006.032755

Mackey, M., Leaver, A., Radas, A., Shirley, D., Chau, J., Engelen, L., . . . Bauman, A. (2015). Do ergonomic and education interventions reduce prolonged occupational sitting? a randomised controlled trial. *Physiotherapy, 101*(1).

MATLAB 8.0 and Statistics Toolbox 8.1, The MathWorks, Inc., Natick, Massachusetts, United States.

Meulenbroek, R. G., Van Galen, G. P., Hulstijn, M., Hulstijn, W., & Bloemsaat, G. (2005). Muscular co-contraction covaries with task load to control the flow of motion in fine motor tasks. *Biol Psychol, 68*(3), 331-352. doi:10.1016/j.biopsycho.2004.06.002

Mitchell Smith, D., Anderson, E., V. Natis, Y., Heiser, J., Bittman T.J.,... Petri,. G. (2015). Predicts 2016: Cloud Computing to Drive Digital Business. *Gartner*. ID: G00292047

Okta. (2015). Business at work. Retrieved June 8, 2016, from https://www.okta.com/Businesses-At-Work/2015-08/

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. *Preventing chronic disease, 9*, E154.

Pronk N.P., Kottke, T.E. (2009). Preventive Medicine. *Elsevier, 49*, 316–321

Roemmich, J. N. (2016). Height-Adjustable Desks: Energy Expenditure, Liking, and Preference of Sitting and Standing. *J Phys Act Health*, 1-20. doi:10.1123/jpah.2015-0397

Schüldt, K., Ekholm, J., Harms-Ringdahl, K., Arborelius, U. P., & Németh, G. (1987). Influence of sitting postures on neck and shoulder e.m.g. during arm-hand work movements. *Clinical Biomechanics, 2*(3), 126-139. doi:http://dx.doi.org/10.1016/0268-0033(87)90003-9

Straker, L., Pollock, C., Burgess-Limerick, R., Skoss, R., & Coleman, J. (2008). The impact of computer display height and desk design on muscle activity during information technology work by young adults. *J Electromyogr Kinesiol, 18*(4), 606-617. doi:10.1016/j.jelekin.2006.09.015

Thorp, A. A., Kingwell, B. A., Owen, N., & Dunstan, D. W. (2014). Breaking up workplace sitting time with intermittent standing bouts improves fatigue and musculoskeletal discomfort in overweight/obese office workers. *Occupational and environmental medicine, 71*(11), 765-771.

Van der Ploeg, H. P., Chey, T., Korda, R. J., Banks, E., & Bauman, A. (2012). Sitting time and all-cause mortality risk in 222–497 Australian adults. Archives of Internal Medicine, 172(6), 494–500.

Vicon Motion Systems. Plug-in gait product guide – foundation notes. Oxford: Vicon Motion Systems, 2010, http://www.irc-web.co.jp/vicon_web/news_bn/PIGManualver1.pdf.

Yoon, H.-S., Soh, J., Bae, Y. J., & Seung Yang, H. (2001). Hand gesture recognition using combined features of location, angle and velocity. Pattern Recognition, 34(7), 1491-1501. doi:10.1016/s0031-3203(00)00096-0

World Health Organization. (2010). The WHO agenda. Retrieved July 17, 2010, from http://www.who.int/about/agenda/en/index.html

2.2 Article 2

When Should I Use my Active Workstation? The impact of Physical Demand and Task Difficulty on IT Users' Perception and Performance
-Complete research-

Marc-Antoine Jutras
HEC Montréal
marc-antoine.jutras@hec.ca

Elise Labonté-Lemoyne
HEC Montréal
elise.labonte-lemoyne@hec.ca

Sylvain Sénécal
HEC Montréal
sylvain.senecal@hec.ca

Pierre-Majorique Léger
HEC Montréal
pierre-majorique.leger@hec.ca

Mickael Begon
Université de Montréal
mickael.begon@umontreal.ca

Marie-Ève Mathieu,
Université de Montréal
me.mathieu@umontreal.ca

ABSTRACT

Seated position in our daily computer interaction has been identified as a major threat for health. Active workstations have been proposed has a healthy solution to these problems. However, research findings on the effects of such workstations on users' performance are not conclusive. We argue that physical demand and task difficulty play a role in influencing IT users' performance and perceptions when suing active workstations. An experiment manipulating task difficulty, direct and indirect physical demands was performed. Results suggest that task difficulty moderates the relationships between direct and indirect physical demand users' perceptions and performance. Findings will help organizations and employees selecting the right task when it comes to using active workstations.

1. INTRODUCTION

The usage of Information Technology (IT) in a seated position in work environments has rapidly evolved over the past decades. While technology can bring major gains to businesses, this technological revolution is one of the main causes of physical inactivity (Straker, Levine et Campbell, 2009). Indeed, sedentarity is now considered the new smoking (Merchant, 2013). For a large proportion of workers, the time they spend sitting is 65 to 75% of their working time (John P Buckley *et al.*, 2015b). This causes important health risks, even among people who adhere to physical activity recommendations. The problem arises from long sitting periods (Van der Ploeg *et al.*, 2012). In addition to the many health risks, research suggests that spending too much time sitting can also affect work performance, absenteeism, work accidents, and can even have an impact on relationships (Pronk *et al.*, 2004; Sliter et Yuan, 2015).

Straker, Levine et Campbell (2009) mention that current health promotion approaches tend to focus on encouraging people to exercise in their leisure time in order to increase physical activity, but such a strategy is failing. Thus, an important question is can people be both active and productive at work. Although active workstations (AW) (see Figure 9) seem to be a promising solution, firms may have concerns before investing in this type of work equipment. Concerns include questions about how it may interfere with employee performance, employee acceptance and continuous usage of such equipment. Research addressing these open questions would help firms make better decisions in this area.

This paper investigates the effects of using an AW in the context of human computer interaction. In this context, AW can be defined as desks that demand light to very light levels of physical activity (Sliter et Yuan, 2015) and that generate more physical demand than simply sitting in front of a computer (Jutras *et al.*, 2017). The objective of this experiment is to investigate how the physical demand of AW and the types of IT tasks influence users' perceptions and performance.

Based on a literature review in both Information Systems and Kinesiology, we propose and empirically test a research model in order to assess which IT tasks is most suited for

AW. Using a within-subject experimental design, an experiment involving 40 participants was performed. The objective of this study is to recommend which type of task is likely to be more optimal while using an AW.

2. LITERATURE REVIEW

The important usage of computers has been reported as negatively impacting physical activity participation. Higher levels of computer use are associated with increased physical inactivity (Owen *et al.*, 2000). Sisson et Katzmarzyk (2008) mention that most adults are generally inactive and physical activity decreases with age, in addition to the lack of understanding of health benefits of exercising even though many diseases have been linked to inactivity. Indeed, inactivity, sedentary, and prolonged sitting time periods, over time have been linked to an increased risk of metabolic illnesses such as heart diseases (Chau *et al.*, 2015), stroke (Chau *et al.*, 2015), diabetes (Højbjerre *et al.*, 2010), obesity (Levine et Miller, 2007), heart failure (Chau *et al.*, 2015), and increased risks of all-cause mortality (Van der Ploeg *et al.*, 2012).

In this context, research suggests that AW could be a viable option for workplaces aiming to provide employees with options to reduce their sitting time (Grunseit *et al.*, 2013). Standing desks, treadmill desks, cycling desks, or exercise balls instead of normal chairs are examples of active workstations. Research shows that "very light to light physical activity can be effective for enhancing psychological well-being by reducing depression" (Sliter et Yuan, 2015 : 2). Researchers also recommend that regular breaks from seated work could help limit those risks (Thorp *et al.*, 2016) as a reduction in sitting time reduces pain in upper back and neck and improves mood (Pronk *et al.*, 2012).

Although the literature is clear about AW health benefits, there are mixed findings on their effect on employee performance. For example, some studies show that there is no difference between sitting and standing in terms of cognitive functions or task productivity (Russell *et al.*, 2016). But, it is also suggested that light physical activity can have cognitive benefits on simpler tasks but also could have deteriorated effects on more complex cognitive functions (E. Labonte-LeMoyne *et al.*, 2015). Since AW can accommodate a variety of IT tasks (Grunseit *et al.*, 2013), we suggest that these mixed findings may in part be due to the different tasks performed and contexts in which prior studies have been conducted; making it difficult to compare and generalize results. These mixed results can be confusing for users in deciding which task should be performed on an AW and in which context.

Task performance depends mainly on physical demand and cognitive demand (Straker, Levine et Campbell, 2009). Evaluating the physical demand of an IT task in an AW context becomes necessary since the whole body is now interacting with the technology and movement becomes a basic element of all interactions (Elise Labonte-LeMoyne *et al.*, 2016). For instance, Jutras *et al.* (2017) show considerable differences in muscle demand as well as the range of motion that office tasks requiring technology generates. Moreover, Fraizer et Mitra (2008) suggest that the effects of physicality might interfere between posture and cognition depending on the difficulty of the task. This could also help explain the mixed findings about the relationship between AW and employee performance.

3. HYPOTHESIS DEVELOPMENT

Based on kinesiology literature, Elise Labonte-LeMoyne *et al.* (2016) propose new constructs applicable to the field of Information Technology and Information Systems. Physical demand can be divided in the physicality of direct and indirect interaction with technology. The physicality of direct interaction is the "quantity and type of movement required from the user to control and interact with the technology" (Elise Labonte-LeMoyne *et al.*, 2016 : 7). It concerns the movement that is performed to accomplish a certain goal. The movement is planned and constantly readjusted according to its sensory feedback in order to control the technology (Elise Labonte-LeMoyne *et al.*, 2016). The physicality of indirect interaction with technology is the "physical positioning and movement of the user's body during the interaction with technology including that which is necessary to support the device" (Elise Labonte-LeMoyne *et al.*, 2016 : 5). Walking on a treadmill or simply standing while performing an IT task is considered an indirect physical interaction.

Thus, in order to better understand the influence of AW on employee performance, these two constructs need to be investigated. As shown in Figure 8 and based on Elise Labonte-LeMoyne *et al.* (2016) we suggest that both types of physicality influence IT users' perceptions (i.e., attention, satisfaction, and stress) and performance (objective and perceived). We suggest that cognitive demand (i.e., the difficulty of the IT task) moderates these relationships.

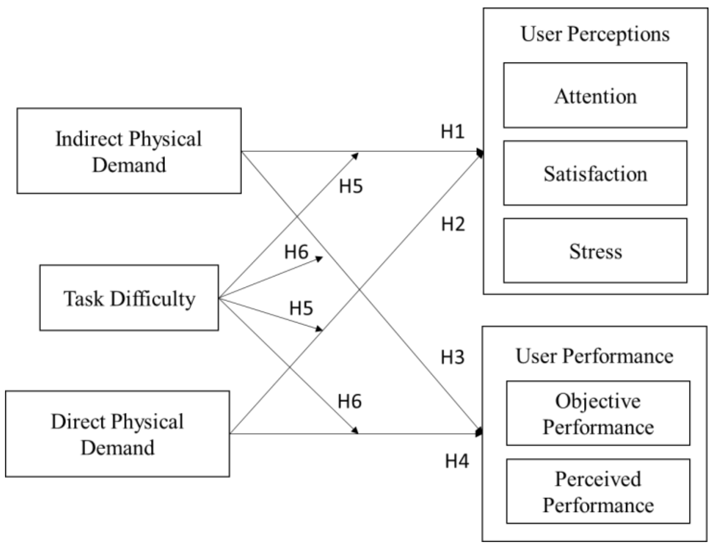

Figure 8: Research Model

The Impact of Physical Demand on User Perceptions

Perceived Attention

We expect an influence of the usage of AW on the perceived attention of the user. Woollacott et Shumway-Cook (2002 : 1) defines attention as "the information processing capacity of an individual." They also suggest that information processing capacity is limited and a task takes a portion of this capacity (Woollacott et Shumway-Cook, 2002). On the one hand, based on this definition, it may be that AW take a certain portion of the user attention. On the other hand, research suggest that exercise positively impacts cognitive functions (i.e., attention) (Kramer *et al.*, 1999). It is also suggested that there is a relationship between postural control (i.e., indirect physical demand) and some aspects of cognition, such as attention, but it would vary greatly depending on the difficulty of the task (Huxhold *et al.*, 2006). Moreover, recent research shows that indirect physical demand has a positive impact on cognitive functions (i.e., memory and attention) for simpler tasks and a negative effect when users perform more difficult tasks (E. Labonte-LeMoyne *et al.*, 2015). Similarly, Benzo *et al.* (2016) suggest that perceived attention and task difficulty interact in AW usage contexts. Thus, it is still unclear if there is or not possible benefits on attention (E. Labonte-LeMoyne *et al.*, 2015). Benefits could simply be canceled out by the difficulty of the task (E. Labonte-LeMoyne *et al.*, 2015).

Perceived Job satisfaction

One of the many goals of a good human and computer interaction is to ensure that the technology can be used with satisfaction (Hartson, 1998). Prior research suggests that AW influence user satisfaction. For instance, in a qualitative study, Dutta, Walton et Pereira (2015) show that the usage of a sit-stand workstation resulted in a positive experience. Participants mentioned that AW usage procured them greater energy and alertness at work and reported increased face-to-face interaction with coworkers (Dutta, Walton et Pereira, 2015). Sliter et Yuan (2015) also suggest that light and very light physical activity seem to be effective in reducing depression and enhancing psychological well-being. In addition, Roemmich (2016) mentions that the usage of an adjustable desk did not alter the hedonic value of standing or sitting. Also, generally physical activity has a positive impact on mood and this might lead to a higher level of task satisfaction (Sliter et Yuan, 2015).

Perceived stress

In a work environment, stress can have a significant impact on the psychological and physiological of the user. Indeed, with the technological revolution came millions of computers in workplaces and it has resulted in many musculoskeletal related complaints due to the work with computers (Smith, Conway et Karsh, 1999). Research suggest that poor workstation design, the cognitive demand of a task, its postural demands, and job demands can contribute to the disturbance of moods, such as higher level of stress and anxiety (Smith, Conway et Karsh, 1999). On the other hand, physical activity helps control weight but can also lower stress levels (Koren, Pisot et Simunic, 2016). John P Buckley *et al.* (2015b) even suggest that firms should promote health measures to reduce stress, where AW could be a possible solution. We thus posit the following hypotheses.

H1: The indirect physical demand has an impact on IT users' perceptions.
H2: The direct physical demand will have an impact on IT users' perceptions.

The Impact of Physical Demand on Task Performance

Objective Performance

There are mixed findings in the literature regarding the influence of AW usage on task performance. To our knowledge, no research has tried yet to explain these findings. In order to better understand this relationship, both types of physical demand need to be taken into account.

Indirect physical demand may influence performance. For instance, Ohlinger *et al.* (2011) questions how the speed of the AW treadmill may affect performance. Direct physical demand may also play a role. Straker, Levine et Campbell (2009) show that performance decrement was slightly larger for mouse tasks than for typing tasks. This could be a product of the different motor control and eye–hand coordination strategies required in typing and mouse pointing (Straker, Levine et Campbell, 2009).

Although, light physical activity has a positive effect on cognitive performance (Chang *et al.*, 2012), various indirect and direct physical demands may also influence performance. Thus, finding the right mix of direct (e.g., IT task) and indirect physical demand (type of AW) is key to improve work performance (Jutras *et al.*, 2017).

Perceived Performance

As shown in Straker, Levine et Campbell (2009) and Commissaris *et al.* (2014), users might perceive a negative effect of using an AW on performance. The fact that users are not accustomed to using such a station also comes into play, which could have a negative impact on performance perception. Commissaris *et al.* (2014) also show that perceived performance was lower in all AW (i.e., walking and cycling) conditions, but not in the standing condition. This suggests that depending on the type of physical demand made by the AW, there could be an impact on perceived performance. Furthermore, perceived performance was also impacted by the types of tasks, depending on their level of motor action (Commissaris *et al.*, 2014). Here it is not the physical demand that is generated by the workstation, but by the task that impacts the perceived performance of the user. We thus posit the following hypotheses.

H3: Indirect physical demand has an impact on perceived and objective IT task performance.
H4: Direct physical demand has an impact on perceived and objective IT task performance.

The Moderating Effect of Task Difficulty

As mentioned, task difficulty is a moderator in this study (Figure 8). By investigating the moderation effect of task difficulty, differentiated effects of direct and indirect physical demand on users' perceptions and performance can be isolated. For instance, if standing demands more indirect physical demand than sitting, a performance decrease could be observed. However, we suggest that this decrease is more severe for more difficult tasks (Damos, 1991).

H5: Task difficulty moderates the relationship between (indirect and direct) physical demand and IT users' perceptions.
H6: Task difficulty moderates the relationship between (indirect and direct) physical demand and task performance.

4. METHODOLOGY

A laboratory experiment was conducted with a sample of 53 participants. A 2 (indirect physical demand: sitting/standing) x 2 (direct physical demand: low or high) x 2 (task difficulty: easy or hard) within-subject design was used. Participants were randomly assigned to either the seated or standing position for the first half of the experiment and they then changed to the other position for the remaining of the experiment, following a 15-minute break. The direct physical demand and the task difficulty conditions were randomized. Based on Jutras *et al.* (2017), participants had to use a touch screen in the high direct physical demand condition and a computer mouse in the low direct physical demand condition. The task consisted of a standardized neuropsychological dual task memory span (Corsi et Michael, 1972), where participants had to memorize a sequence of numbers and a sequence of letters (See below for details). This test was selected because it induces cognitive states that are representative of office IT tasks, it could be performed on either a touch screen or with a mouse, and it can be manipulated in order to be easy or demanding in terms of cognitive load. The sequence to be memorized during the task was longer in the hard task difficulty condition than in the easy task difficult condition. Thus, each participant performed 8 tasks (i.e., sitting-mouse-easy, sitting-mouse hard, sitting-touchscreen-easy, etc.).

A sit-stand AW (30 inches x 60 inches) was used (Anthrodesk, Etobicoke). The desk was adjusted with the up and down arrows of the numeric control panel integrated to the desk. The height of the standing condition was adjusted to the participant’s size. With the participants’ arms at 90 degrees, we adjusted the desk until it touched their arms. When they were standing, we placed an anti-stress carpet under their feet. For the sitting condition, the chair did not move. The screen used was a 23-inch Touchscreen LED Monitor (Acer, New Taipei City).

Figure 9: Experimental Setup (Standing condition)

Participants

Of the 53 participants, the data of 40 participants (40% of women) was usable for the final analysis due to technical difficulties and participants who did not meet the criteria for the study (e.g., health issues). Participants were university students. Participants had to be 18 and over and each was screened for neurological diagnostics, physical conditions, or any other health issue that could interfere with the experiment. Based on the Body Mass Index (BMI) standard, 72.5% of them had a BMI in the range of a normal weight; which is between 18.5 and 24.9 (Table 4). Each participant received a 50$ gift card as a compensation.

Characteristics	Mean	Standard Deviation
Age (years)	24.1	5.1
Weight (kg)	71.5	14.5
Height (cm)	174.2	10.8
BMI (kg/m2)	23.5	3.8

Table 4: Sample Description (n=40)

Procedure

The study was approved by our institution's Ethical Research Board and participants had to provide their informed consent to participate. In addition to the 8 experimental tasks, a practice task was first performed to eliminate potential task related learning biases.

After each task, participants completed a questionnaire to assess their task perceptions (attention, satisfaction, stress, and performance). Finally, they complete a questionnaire containing demographic questions and in which their general comments on the use of active stations were also collected.

Tasks

The task performed for all 8 conditions consisted of an adapted version of the Corsi block tapping task that assesses visuo-spatial working memory (Corsi et Michael, 1972), a cognitive process involved in office multitasking. This standardized test was used in order to properly evaluate performance and measure the spatial working memory (WM) of the participants. WM measures the functional importance of an immediate memory system that could briefly store a limited amount of information in the service of ongoing mental activity (Conway *et al.*, 2005). There was also a dual task aspect involved in the experiment where there were two sources of data one from the processing component (Numbers) of the task and one of the storage component (Letters).

Participants had to memorize a sequence of numbers (6 numbers in the hard condition and 3 in the easy condition) first displayed at the screen. On the next screen, a letter appeared. Then, on the next screen, the participant had to enter the sequence of numbers that was displayed on the first screen by clicking/touching the squares in the correct order. Participant had to perform these 5 times for the hard task (i.e., 5 letters to remember) and 2 for the easy task (i.e., 2 letters to remember). Finally, the participant was asked to reproduce, in the correct order, the letters that appeared between the sequences of the numbers. In the hard task condition, the participant had to do this whole process 3 times and 9 times in the easy task condition.

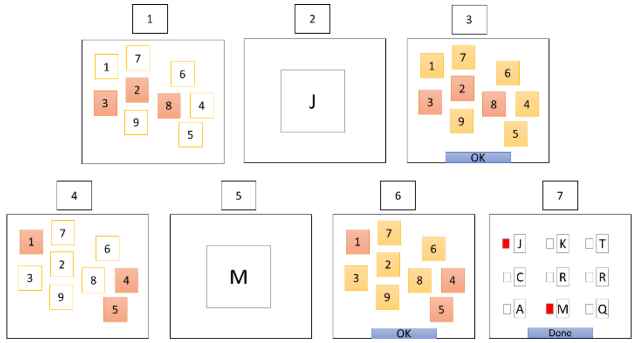

Figure 10: Example of an easy task. Participant first memorize a sequence of numbers (numbers in orange are highlighted one by one to form a sequence). Then a letter appears. After, he must enter the sequence of numbers seen in the first screen, in the correct order, in the third screen. He has to do this another time. In the 7th screen, he must enter, in the correct order, the letter J and then the letter M, before clicking “Done”. An easy task represents 9 times this process.

The participant also had the opportunity to select the option “Unknown Letter” if he did not remember a letter so s/he could have the next one in the correct order while reproducing the letters. The test was run using the psychology software tool E-prime (Sharpsburg, USA). The length of each task was made to accommodate the research design. The easy and hard task were both about 4-5 minutes, depending on the participant's speed.

In order to evaluate the performance of the participants, we proceeded to an evaluation based on all or nothing unit scoring (Conway *et al.*, 2005) where we attribute 1 point for each right answer. We then calculated the proportion of right answers for each sequence and calculated an average of the total score for each of the 8 tasks. The score of the sequence of numbers was calculated separately from the score of the letters because they may induce different cognitive loads. Thus, we had two final scores, one for the sequence of numbers [Number Score (%)] and one of the sequences of letters [Letter Score (%)].

We also measured the average reaction time (RT) of the sequences of numbers and letters, because speed may influence score. For example, one may take more time for a harder task to avoid making mistakes (Heitz, 2014). RT was measured in milliseconds. We have the RT for the letters [Average Letter RT] that was calculated from the time spent on the screen entering the letter that appeared between the sequences of numbers and the RT for the numbers [Average Stimulus RT] that calculated the time to redo the sequence of numbers

We also used the Inverse Efficiency Score (IES) (Townsend et Ashby, 1983). IES is defined as an observable measure that gauges the average energy consumed by the system over time (Townsend et Ashby, 1983). It basically combines speed and error and it is calculated by dividing the reaction time with the % of correct response. We calculated the IES for the letters [Letter IES] and IES for the numbers [Number IES].

Measurement Scales

Table 5 presents the measurement scales used in the study.

Variable Name	**Definition**	**Measure**	**Source**
Satisfaction	Satisfaction perceived for a task.	3 items. Participants had to score different satisfaction levels from 0 to 100.	(Sirdeshmukh, Singh et Sabol, 2002)
Stress	The level of stress of the participant for a task.	1 item answered with a 7-point Likert. 1=No Stress and 7=Caused me Panic	(Beaudry et Pinsonneault, 2005)
Attention	Self-perceived on task attention	6 items answered with a 7-point Likert. 1=Completely Disagree and 7=Completely Agree	(Kanfer et Ackerman, 1989)
Performance	The participant was asked how he performed on the task.	Participants had to score their perceived performance in percentage after each task.	(Commissaris *et al.*, 2014)

Table 5: Measurement scales

Some personal factors might have an impact on our key variables. Thus, the following control variables were used: BMI, self-perceived cardiovascular conditions, need for touch, and gender. Having participants' level of fitness is relevant considering that the profile may vary from possible users of active stations. The Need For Touch (Peck et Childers, 2003) is a trait that represents an individual's preference for haptic feedback. This is used to control the variations affecting the usage of a touch screen. Gender could help identify if there are any particular differences in the preference of the design of a task regarding its physical demand.

5. RESULTS

Indicator skewness and kurtosis were computed in order to see the normalization and the distribution of the independent and dependent variables. While looking into the distribution, 68% of participants responded that they had a level of perceived attention greater than 5 on a scale of 7. In order to correct critical mass in the distribution, a dummy of the variable Attention was created [Dummy Attention]. We normalized the data of the Average Stimulus RT, Average letter RT, Letter IES, Number IES by analyzing them with their logarithm (log (x +1)). The controlled variable NFT was computed by averaging the score of its 12 items. We also created the variable Dummy Female where if a participant is a woman, we would enter 1 and 0 if the participant was a man.

Statistical analyses were performed with Statistical Product and Service Solutions (SPSS) version 24 and Stata version 14. The independence of the independent variables, as well as the impact of the independent variables on the dependencies, are examined with a Pearson correlation matrix as well as for the descriptive statistics for the studied variables.

To examine the relationships hypothesized, we used multiple linear regression of least squares as well as logistic regression for the variable Dummy Attention. The two types of regressions correct the non-independence of the observations by the vce cluster id subject (adjustment of the error standard due non-independence of the observations due to repeated measures). With this procedure, we correct the standard deviation of the coefficient and its p-value.

To verify the potential effects of moderation or quasi-moderation (Sharma, Durand et Gur-Arie, 1981) of the difficulty of the task, we perform linear and hierarchical regressions. Finally, multicollinearity was tested using the VIF (variance inflation factor); No VIF of the independent variables exceeded 3.

User Perceptions

Hypotheses 1 and 3

The indirect physical demand (sitting and standing) had no significant impact on users' perceptions (Attention, Satisfaction, Stress, and Performance). Thus, H1 and H3 (perceived performance) are rejected. However, there is an interesting finding where satisfaction is positively impacted when the indirect physical demand is closer to 1 (the standing position) (3.037, p≤0.10). Results are displayed in Table 6.

Hypotheses 2 and 4

Direct physical demand negatively influences users' perceptions. Direct physical demand (touch screen) has a significant impact on Satisfaction (-3.038, p≤0.05) and a marginally significant impact on Attention (-0.0899, p≤0.1), Performance (-1.763, p≤ 0.10) and Stress (which is on an inverse scale, so it has a positive coefficient when using the touch screen resulting in an increasing level of stress (0.125, p≤0.10)). Thus, results support both H2 and H4 (perceived performance).

Some control variables were significant. When the user had a better cardiovascular condition, significantly, the Satisfaction has a higher score (8.270, p≤0.10). Also, participants scored higher on the scale of Attention when they had higher cardiovascular capabilities (0.515, p≤ 0.05). Need For Touch impacted the dummy value of Attention. Higher NFT brought higher level of attention (0.563, p≤0.01).

	Satisfaction		Stress		Attention		Dummy Attention		Performance	
	Coef.		Coef.		Coef.		Coef.		Coef.	
	(Std.Err.)	Sig[2]	(Std.Err.)	Sig[2]	(Std.Err.)	Sig[2]	(Std.Err.)	Sig[2]	(Std.Err.)	Sig[2]
Random	0.068		-0.098	****	0.017		0.049		0.038	
	(0.365)		(0.023)		(0.018)		(0.076)		(0.343)	
BMI	1.039		-0.023		0.078	**	0.271	***	-0.709	
	(0.816)		(0.037)		(0.035)		(0.104)		(0.479)	
Dummy Female	-1.794		0.193		0.145		0.481		-8.793	*
	(6.651)		(0.327)		(0.350)		(0.752)		(4.472)	
Self perceived Cardio	8.270	*	-0.348		0.515	**	2.097	****	-1.308	
	(4.301)		(0.212)		(0.209)		(0.620)		(3.424)	
Average NFT	-1.517		0.105		0.125		0.563	***	0.065	
	(1.690)		(0.089)		(0.077)		(0.214)		(1.264)	
Indirect Physical Demand	3.038	*	0.025		0.102		0.037		0.738	
	(1.751)		(0.099)		(0.078)		(0.299)		(1.497)	
Direct Physical Demand	-3.038	**	0.125	*	-0.090	*	-0.049		-1.763	*
	(1.428)		(0.073)		(0.047)		(0.155)		(0.898)	
Task Difficulty	-22.502	****	1.009	****	-0.336	****	-0.697	**	-36.931	****
	(2.789)		(0.119)		(0.088)		(0.292)		(3.030)	
Constant	40.635		3.741	***	2.142	*	-11.390	****	112.758	****
	(29.356)		(1.133)		(1.205)		(3.587)		(17.948)	
R2	0.273		0.248		0.142		0.229		0.551	
P-value	0.000		0.000		0.000		0.005		0.000	

1. Logarithm transformation function

2. Two tail level of significance: * $P \leq 0.10$; ** $p \leq 0.05$; *** $p \leq 0.01$; **** $p \leq 0.001$

Table 6: User Perception Results

Hypotheses 3-4

Hypotheses H3 and H4 (objective performance) were tested simultaneously. We tested multiple variable of the task performance individually (i.e., Letter Score (%), Number Score (%), Average Stimulus RT, Average letter RT, Letter IES, Number IES).

Indirect physical demand had a significant effect on Number Score (%). It was higher in the standing condition (3.215, $p \leq 0.01$). Indirect physical demand did not impact other task performance variables. Thus, H3 (objective performance) is partially supported.

The more there was a direct physical demand, the more it had a negative and significant impact on all performance variables (Letter Score (%): -5.340, p≤0.001; Number Score: -5.461, p≤0.001; Average Stimulus (RT): 0.500, p≤0.001; Average letter (RT): 0.242, p≤0.001; Letter IES: 0.294, p≤0.001; Number IES: 0.580, p≤ 0.001). Thus, H4 (objective performance) is supported.

Again, some control variables were significant in relation to objective task performance. Higher value in NFT negatively impacted the score of the numbers, RT, and IES (Number Score (%): -1.686, p≤0.05; Average Stimulus (RT): 0.057, p≤0.01; Average letter (RT): 0.064, p≤0.01; Letter IES: 0.053, p≤ 0.10; Number IES: 0.085, p≤0.01). Also, the more the experiment advanced, a decrease of RT was observed (Average Stimulus (RT): -0.031, p≤0.001; Average letter (RT): -0.040, p≤0.001; Letter IES: -0.057, p≤0.001; Number IES: -0,031, p≤0.001).

	Letter Score (%)		Number Score (%)		Average Stimulus (RT)[1]		Average letter (RT)[1]		Letter IES[1]		Number IES[1]	
	Coef. (Std.Err.)	Sig[2]	Coef. (Std.Err.)	Sig[2]	Coef. (Std.Err.)	Sig[2]	Coef. (Std.Err.)	Sig[2]	Coef. (Std.Err.)	Sig[2]	Coef. (Std.Err.)	Sig[2]
Random	1.416	***	0.062		-0.031	****	-0.040	****	-0.057	****	-0.031	****
	(0.444)		(0.202)		(0.005)		(0.007)		(0.013)		(0.006)	
BMI	0.091		-0.346		-0.003		0.002		0.001		0.003	
	(0.674)		(0.372)		(0.007)		(0.007)		(0.019)		(0.010)	
Dummy Female	-8.835	*	-7.838	**	0.028		0.093		0.235	*	0.158	
	(4.622)		(3.270)		(0.069)		(0.062)		(0.119)		(0.097)	
Self perceived Cardio	-1.574		-1.788		-0.007		-0.040		-0.024		0.032	
	(3.872)		(2.452)		(0.041)		(0.040)		(0.090)		(0.066)	
Average NFT	0.743		-1.687	**	0.057	***	0.064	****	0.053	*	0.085	***
	(1.389)		(0.834)		(0.018)		(0.012)		(0.031)		(0.025)	
Indirect Physical Demand	2.396		3.215	***	0.000		-0.036		-0.050		-0.045	
	(1.814)		(1.008)		(0.021)		(0.028)		(0.053)		(0.027)	
Direct Physical Demand	-5.340	****	-5.461	****	0.500	****	0.242	****	0.293	****	0.580	****
	(1.457)		(1.522)		(0.036)		(0.032)		(0.059)		(0.041)	
Task Difficulty	-41.638	****	-21.886	****	0.800	****	0.975	****	1.774	****	1.104	****
	(4.463)		(2.597)		(0.029)		(0.047)		(0.122)		(0.053)	
Constant	89.462	****	119.203	****	7.715	****	8.225	****	8.348	****	7.345	****
	(19.158)		(13.914)		(0.205)		(0.224)		(0.535)		(0.362)	
R2	0.488		0.436		0.774		0.752		0.685		0.765	
P-value	0.000		0.000		0.000		0.000		0.000		0.000	

1. Logarithm transformation function

2. Two tail level of significance: * p ≤ 0.10; ** p ≤ 0.05; *** p ≤ 0.01; **** p ≤ 0.001

Table 7: Objective Performance Results

Hypotheses 5 and 6

In order to test the moderation effect for task difficulty, we tested a two-tailed level of significance for Fisher's test that compares the coefficient and to check the p-value of the moderator effect (Table 8). By comparing an easy and hard task with direct and indirect conditions, we can conclude that the difficulty of the task is strongly significant for each condition. The difficulty of the task is a moderator. The difficulty of the task is then considered has a “quasi-moderator” since it is also a predictor of the dependent variables (Sharma et al. 1981).

So far, the results do not make it possible to determine whether for an easy / difficult task, it is preferable to perform it in a sitting or standing position with a mouse or a touch screen. In order to do this, we can also look at the p-value of the Fisher test that compares the coefficients.

In Table 8, the column Indirect (p.d.) compares sitting and standing for an easy task, the second column compares sitting and standing for a difficult task. For an easy task, there is a significant difference for the Satisfaction, Number Score (%), and Number IES; where there is a preference for standing condition since the coefficient is higher in row 3 of Table 8. For a difficult task, standing could enhance the Number Score (%). The first column of Direct (p.d) compares mice and touch screen tasks in the easy condition and the second one in the difficult condition. For an easy task, results indicate a better perceptions and performance in the mouse condition (less direct physical demand). For a harder task, only the objective task performance is impacted negatively by the touch screen (greater direct physical demand), users’ perceptions were not impacted.

Overall, results suggest that task difficulty moderates the relationships between indirect physical demand and users’ perceptions (attention, satisfaction, and stress; Table 8, columns 13-14) and between direct physical demand and users’ (objective and perceived) performance (columns 15-16), thus H5 and H6 are supported.

	Seated				Standing				Mouse				Touch				Sig[1] 1 vs 3	Sig[1] 2 vs 4	Sig[1] 5 vs 7	Sig[1] 6 vs 8	Sig[1] 1 vs 2	Sig[1] 3 vs 4	Sig[1] 5 vs 6	Sig[1] 7 vs 8
	1		2		3		4		5		6		7		8		Indirect (p.d)[4]		Direct (p.d)[4]		Task Difficulty[4]			
	Easy		Hard		Easy		Hard		Easy		Hard		Easy		Hard									
	Coef.	Sig[3]	Coef.	Sig[3]	Coef.	Sig[3]	Coef.	Sig[3]	Coef.	Sig[3]	Coef.	Sig[3]	Coef.	Sig[3]	Coef.	Sig[3]								
Satisfaction	40.580	ns	18.176	ns	43.715	ns	21.117	ns	43.545	ns	17.213	ns	36.677	ns	16.006	ns	*		***		****	****	****	****
Stress	3.797	***	4.705	****	3.721	***	4.831	****	3.691	***	4.801	****	3.917	****	4.825	****			**		****	****	****	****
Attention	2.129	*	1.815	ns	2.253	*	1.895	ns	2.157	*	1.790	ns	2.036	ns	1.731	ns			**		****	***	****	***
Dummy Attention	-11.433	***	-12.063	****	-11.321	****	-12.085	****	-11.227	***	-12.377	****	-11.772	****	-12.045	****			**		**		***	
Performance	112.724	****	75.853	****	113.522	****	76.530	****	113.417	****	75.160	****	110.329	****	74.723	****			***		****	****	****	****
Letter Score (%)	89.748	****	47.597	**	91.632	****	50.505	**	88.756	****	48.538	**	84.836	****	41.778	**			***	**	****	****	****	****
Number Score (%)	119.555	****	97.036	****	122.138	****	100.883	****	118.893	****	97.629	****	114.055	****	91.547	****	**	**	***	***	****	****	****	****
Average Stimulus (RT)[2]	7.728	****	8.504	****	7.705	****	8.528	****	7.689	****	8.541	****	8.242	****	8.989	****			****	****	****	****	****	****
Average letter (RT)[2]	8.214	****	9.208	****	8.197	****	9.152	****	8.183	****	9.241	****	8.508	****	9.400	****			****	***	****	****	****	****
Letter IES[2]	8.341	****	10.130	****	8.304	****	10.064	****	8.312	****	10.163	****	8.682	****	10.376	****			****	*	****	****	****	****
Number IES[2]	7.351	****	8.444	****	7.295	****	8.409	****	7.330	****	8.464	****	7.940	****	9.014	****	*		****	****	****	****	****	****

1. Two tail level of significance for Fisher test (comparison between the coefficients): * $p \leq 0.10$; ** $p \leq 0.05$; *** $p \leq 0.01$; **** $p \leq 0.001$
2. Logarithm transformation function
3. Two tail level of significance for coefficients: * $p \leq 0.10$; ** $p \leq 0.05$; *** $p \leq 0.01$; **** $p \leq 0.001$
4. Moderator effect

Table 8: Moderation Results

6. DISCUSSION

Latest studies suggest that the concept of "metabolically healthy obesity " no longer exists and that a population-wide strategy to tackle obesity is needed (Lassale *et al.*, 2017). Since a large portion of IT users' work time is spent seating, organizations need to be involved in the development of this population-wide strategy. They also are directly affected by these issues since health and work are quite related and that health issues could significantly affect work performance (Pronk *et al.*, 2004). Considering that sit-stand workstations propose higher levels of energy expenditure (Reiff, Marlatt et Dengel, 2012) and could reduce obesity, implementing them would be beneficial for both health and work performance benefits.

However, mixed findings in the literature about the relationship between active workstations and work performance do not make it easy for organizations to conclude on potential performance benefits. Thus, the objective of this study was to inform researchers and managers about the effects of active workstation physical demand and task difficulty on IT users' perceptions and performance.

We hypothesized that indirect physical demand would have an impact on users' perceptions (H1) and task performance (H3). Our results suggest that indirect physical demand has no impact on users' perceptions (H1). Similar findings have been reported in other studies where the hedonic value of standing or sitting is not impacted by an active workstation (Roemmich, 2016). This is promising for the usage of active workstations.

At the performance level, with the results of H3, we can conclude that a higher level of indirect physical demand might bring benefits of using workstations for some tasks. These results are similar to those of E. Labonte-LeMoyne *et al.* (2015) where performance for users of an active workstation was better than the people that performed the same task in a seated condition. Even though it affected only the score of the numbers, the fact that it did not negatively impact the score of the letter nor RT and IES, can suggest that standing will not impact performance and in some situations, it may even improve. This is also in line with the results of Chau *et al.* (2016) where productivity is not affected by the standing position.

We also hypothesized that direct physical demand would have an impact on users' perceptions (H2) and task performance (H4). Results suggest that the more there is direct physical demand, the more it negatively affects user's perception (H2) in the context of an easy task. For both easy and hard tasks, performance (H4) is negatively affected by the usage of the touch screen (higher physical demand). Combining these findings with studies about task accuracy is of interest. For instance, Commissaris *et al.* (2014) conclude that accuracy, for a short task, is strongly affected by an active workstation. Tasks with low direct physical demand that do not require too much accuracy could make a better fit of the active workstations. An interesting result is that the user perception was not significantly impacted for the direct physical demand (mouse, touch) for a harder task. We can suggest that participant focused more on the difficulty of the task than on the movement needed by the touch screen. This suggest that potential benefits are simply canceled out by the difficulty of the task (E. Labonte-LeMoyne *et al.*, 2015).

Feedback from participants can also give us further insight on the usage of active workstation. A majority of participants suggested that the active workstation should only be used for a limited time and alternating the seated and standing position is a must to avoid possible back and leg pain. It has also been suggested that the standing position can help be more alert and can also help in situations that needs creativity. Many comments suggested that the touch screen interaction was not difficult, which also confirmed our concerns regarding the technology that wasn't well aligned with the active workstation. This suggest that ensuring proper ergonomics is important and that the usage of the active workstations is not for all types of jobs. Similarly, a harder task did not have any impact on perceptions. But results suggest that for an easy task, generally, standing generates better perceptions. As suggested by prior research, active workstations might have psychological benefits to individuals (Sliter et Yuan, 2015), report a higher level of satisfaction than a conventional desk, increase alertness, and also reported increased interactions with coworkers (Dutta, Walton et Pereira, 2015).

Limitations

As with any experimental work, this study has limitations. First, the standardized task used as the experimental stimulus provided high internal validity, but lesser external validity. Thus, future work could build on our findings and use more authentic every day IT tasks. Second, in order to increase the representativity of our findings, additional research using samples with different demographic profiles is needed. Finally, research on the design of IT that is more suited to active workstations is needed, in order for users to manage both indirect and direct physical demand without negatively affecting their performance.

Contribution and Implications

To our knowledge, this study is the first to investigate the interaction between physical demand and task difficulty on user performance in the context of active workstations. The proposed research model is a first step toward better understanding the impact of physical demand on performance. For managers, our findings can help them determining what type of task should be performed on active workstations and also contribute to develop strategies that will fight the epidemic of sedentarity and obesity. Proposing and promoting specific tasks could improve implementation time and reassure users about their performance.

Acknowledgement: The Social Sciences and Humanities Research Council of Canada and Canadian Institutes of Health Research provided financial support for the research Thanks to all FIT24 partners, including AnthroDesk for the equipment provided.

References

Beaudry, A. et A Pinsonneault (2005). « Understanding user responses to information technology: A coping model of user adaptation », *MIS quarterly*, p. 493-524.

Ben-Ner, A., D. J. Hamann, G. Koepp, C. U. Manohar et J. Levine (2014). « Treadmill workstations: The effects of walking while working on physical activity and work performance », *PLoS ONE*, vol. 9 (2) (no pagination), no e88620.

Benzo, R. M., A. L. Gremaud, M. Jerome et L. J. Carr (2016). « Learning to stand: The acceptability and feasibility of introducing standing desks into college classrooms », *International Journal of Environmental Research and Public Health*, vol. 13 (8) (no pagination), no 823.

Buckley, J. P., A. Hedge, T. Yates, R. J. Copeland, M. Loosemore, M. Hamer, *et al.* (2015a). « The sedentary office: An expert statement on the growing case for change towards better health and productivity », *Br J Sports Med*, vol. 49, no 21, p. 1357-1362.

Buckley, John P, Alan Hedge, Thomas Yates, Robert J Copeland, Michael Loosemore, Mark Hamer, *et al.* (2015b). « 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 », *Br J Sports Med*, p. bjsports-2015-094618.

Chang, Yu-Kai, JD Labban, JI Gapin et Jennifer L Etnier (2012). « The effects of acute exercise on cognitive performance: A meta-analysis », *Brain research*, vol. 1453, p. 87-101.

Chau, J. Y., A. Grunseit, K. Midthjell, J. Holmen, T. L. Holmen, A. E. Bauman, *et al.* (2015). « Sedentary behaviour and risk of mortality from all-causes and cardiometabolic diseases in adults: Evidence from the hunt3 population cohort », *Br J Sports Med*, vol. 49, no 11, p. 737-742.

Chau, J. Y., W. Sukala, K. Fedel, A. Do, L. Engelen, M. Kingham, *et al.* (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 » [Journal: Article], *Preventive Medicine Reports*, vol. 3, p. 68-74.

Commissaris, D. A., R. Konemann, S. Hiemstra-van Mastrigt, E. M. Burford, J. Botter, M. Douwes, *et al.* (2014). « Effects of a standing and three dynamic workstations on computer task performance and cognitive function tests » [Randomized Controlled Trial. Research Support, Non-U.S. Gov't], *Applied ergonomics*, vol. 45, no 6, p. 1570-1578.

Conway, Andrew RA, Michael J Kane, Michael F Bunting, D Zach Hambrick, Oliver Wilhelm et Randall W Engle (2005). « Working memory span tasks: A methodological review and user’s guide », *Psychonomic bulletin & review*, vol. 12, no 5, p. 769-786.

Corsi, Philip M et Philip Michael (1972). *Human memory and the medial temporal region of the brain*, vol. 34, McGill University Montreal.

Damos, Diane (1991). *Multiple task performance*, CRC Press.

Drury, C. G., Y. L. Hsiao, C. Joseph, S. Joshi, J. Lapp et P. R. Pennathur (2008). « Posture and performance: Sitting vs. Standing for security screening », *Ergonomics*, vol. 51, no 3, p. 290-307.

Dutta, N., T. Walton et M. A. Pereira (2015). « Experience of switching from a traditional sitting workstation to a sit-stand workstation in sedentary office workers » [Journal: Article], *Work (Reading, Mass.)*, vol. 52, no 1, p. 83-89.

Fraizer, Elaine Vida et Subhobrata Mitra (2008). « Postural costs of performing cognitive tasks in non-coincident reference frames », *Experimental brain research*, vol. 185, no 3, p. 429-441.

Grunseit, A. C., J. Y. Y. Chau, H. P. van der Ploeg et A. Bauman (2013). « "Thinking on your feet": A qualitative evaluation of sit-stand desks in an australian workplace », *BMC public health*, vol. 13, p. 365.

Hartson, H Rex (1998). « Human–computer interaction: Interdisciplinary roots and trends », *Journal of Systems and Software*, vol. 43, no 2, p. 103-118.

Heitz, Richard P (2014). « The speed-accuracy tradeoff: History, physiology, methodology, and behavior », *Frontiers in neuroscience*, vol. 8.

Højbjerre, Lise, Mette Paulli Sonne, Amra Ciric Alibegovic, Flemming Dela, Allan Vaag, Jens Bruun Meldgaard, *et al.* (2010). « Impact of physical inactivity on subcutaneous adipose tissue metabolism in healthy young male offspring of patients with type 2 diabetes », *Diabetes*, vol. 59, no 11, p. 2790-2798.

Huxhold, Oliver, Shu-Chen Li, Florian Schmiedek et Ulman Lindenberger (2006). « Dual-tasking postural control: Aging and the effects of cognitive demand in conjunction with focus of attention », *Brain research bulletin*, vol. 69, no 3, p. 294-305.

Jutras, M. A., E. Labonte-LeMoyne, P. M. Leger, S. Senecal, M. E. Mathieu et M. Begon (2017). « An exploratory quantitative investigation of physical demand in everyday information technology usage », communication présentée au *Administrative Sciences Association of Canada*, May 30, Montreal. Récupéré de https://www.researchgate.net/publication/317267062_An_exploratory_quantitative_investigation_of_physical_demand_in_everyday_information_technology_usage

Kanfer, Ruth et Phillip L Ackerman (1989). « Motivation and cognitive abilities: An integrative/aptitude-treatment interaction approach to skill acquisition », *Journal of applied psychology*, vol. 74, no 4, p. 657.

Karakolis, T. et J. P. Callaghan (2014). « The impact of sit-stand office workstations on worker discomfort and productivity: A review », *Appl Ergon*, vol. 45, no 3, p. 799-806.

Koren, K., R. Pisot et B. Simunic (2016). « Active workstation allows office workers to work efficiently while sitting and exercising moderately », *Applied Ergonomics*, vol. 54, p. 83-89.

Kramer, Arthur F, Sowon Hahn, Neal J Cohen, Marie T Banich, Edward McAuley, Catherine R Harrison, *et al.* (1999). « Ageing, fitness and neurocognitive function », *Nature*, vol. 400, no 6743, p. 418.

Labonte-LeMoyne, E., R. Santhanam, P. M. Leger, F. Courtemanche, M. Fredette et S. Senecal (2015). « The delayed effect of treadmill desk usage on recall and attention » [Article], *Computers in Human Behavior*, vol. 46, p. 1-5.

Labonte-LeMoyne, Elise, Pierre-Majorique Leger, Sylvain Senecal et Radhika Santhanam (2016). « Physical interaction with technology: Kinesiology as a reference discipline for information systems research ».

Lassale, Camille, Ioanna Tzoulaki, Karel GM Moons, Michael Sweeting, Jolanda Boer, Laura Johnson, *et al.* (2017). « Separate and combined associations of obesity and metabolic health with coronary heart disease: A pan-european case-cohort analysis », *European Heart Journal*.

Levine, J. A. et J. M. Miller (2007). « The energy expenditure of using a "walk-and-work" desk for office workers with obesity », *British Journal of Sports Medicine*, vol. 41, no 9, p. 558-561.

Ohlinger, C. M., T. S. Horn, W. P. Berg et R. H. Cox (2011). « The effect of active workstation use on measures of cognition, attention, and motor skill », *J Phys Act Health*, vol. 8, no 1, p. 119-125.

Owen, Neville, Eva Leslie, Jo Salmon et Michael J Fotheringham (2000). « Environmental determinants of physical activity and sedentary behavior », *Exercise and sport sciences reviews*, vol. 28, no 4, p. 153-158.

Peck, Joann et Terry L Childers (2003). « Individual differences in haptic information processing: The “need for touch” scale », *Journal of Consumer Research*, vol. 30, no 3, p. 430-442.

Pollack, Keshia M, Gary S Sorock, Martin D Slade, Linda Cantley, Kanta Sircar, Oyebode Taiwo, *et al.* (2007). « Association between body mass index and acute traumatic workplace injury in hourly manufacturing employees », *American journal of epidemiology*, vol. 166, no 2, p. 204-211.

Pronk, N. P., A. S. Katz, M. Lowry et J. R. Payfer (2012). « Reducing occupational sitting time and improving worker health: The take-a-stand project, 2011 », *Preventing chronic disease*, vol. 9, p. E154.

Pronk, N. P., B. Martinson, R. C. Kessler, A. L. Beck, G. E. Simon et P. Wang (2004). « The association between work performance and physical activity, cardiorespiratory fitness, and obesity », *J Occup Environ Med*, vol. 46, no 1, p. 19-25.

Reiff, C., K. Marlatt et D. R. Dengel (2012). « Difference in caloric expenditure in sitting versus standing desks » [Randomized Controlled Trial], *Journal of physical activity & health*, vol. 9, no 7, p. 1009-1011.

Roemmich, J. N. (2016). « Height-adjustable desks: Energy expenditure, liking, and preference of sitting and standing », *J Phys Act Health*, p. 1-20.

Russell, B. A., M. J. Summers, P. J. Tranent, M. A. Palmer, P. D. Cooley et S. J. Pedersen (2016). « A randomised control trial of the cognitive effects of working in a seated as opposed to a standing position in office workers », *Ergonomics*, vol. 59, no 6, p. 737-744.

Sharma, Subhash, Richard M Durand et Oded Gur-Arie (1981). « Identification and analysis of moderator variables », *Journal of marketing research*, p. 291-300.

Sirdeshmukh, Deepak, Jagdip Singh et Barry Sabol (2002). « Consumer trust, value, and loyalty in relational exchanges », *Journal of marketing*, vol. 66, no 1, p. 15-37.

Sisson, SB et PT Katzmarzyk (2008). « International prevalence of physical activity in youth and adults », *Obesity Reviews*, vol. 9, no 6, p. 606-614.

Sliter, M. et Z. Yuan (2015). « Workout at work: Laboratory test of psychological and performance outcomes of active workstations » [Journal: Article], *Journal of occupational health psychology*, vol. 20, no 2, p. 259-271.

Smith, Michael J, Frank T Conway et Ben-Tzion Karsh (1999). « Occupational stress in human computer interaction », *Industrial health*, vol. 37, no 2, p. 157-173.

Straker, L., J. Levine et A. Campbell (2009). « The effects of walking and cycling computer workstations on keyboard and mouse performance », *Human factors*, vol. 51, no 6, p. 831-844.

Thorp, A. A., B. A. Kingwell, C. English, L. Hammond, P. Sethi, N. Owen*, et al.* (2016). « Alternating sitting and standing increases the workplace energy expenditure of overweight adults », *J Phys Act Health*, vol. 13, no 1, p. 24-29.

Thorp, A. A., B. A. Kingwell, N. Owen et D. W. Dunstan (2014). « Breaking up workplace sitting time with intermittent standing bouts improves fatigue and musculoskeletal discomfort in overweight/obese office workers » [Controlled Clinical Trial. Research Support, Non-U.S. Gov't], *Occupational and environmental medicine*, vol. 71, no 11, p. 765-771.

Torbeyns, T., S. Bailey, B. de Geus et R. Meeusen (2015). « The use of cycling workstations in public places - an observational study », *Public Health*, vol. 129, no 11, p. 1439-1443.

Townsend, James T et F Gregory Ashby (1983). *Stochastic modeling of elementary psychological processes*, CUP Archive.

Van der Ploeg, Hidde P, Tien Chey, Rosemary J Korda, Emily Banks et Adrian Bauman (2012). « Sitting time and all-cause mortality risk in 222 497 australian adults », *Archives of internal medicine*, vol. 172, no 6, p. 494-500.

Wilks, S., M. Mortimer et P. Nylen (2006). « The introduction of sit-stand worktables; aspects of attitudes, compliance and satisfaction » [Article], *Applied Ergonomics*, vol. 37, no 3, p. 359-365.

Woollacott, Marjorie et Anne Shumway-Cook (2002). « Attention and the control of posture and gait: A review of an emerging area of research », *Gait & posture*, vol. 16, no 1, p. 1-14.

CHAPITRE 3 : CONCLUSION DU MÉMOIRE

Ce mémoire a pour principaux objectifs d'arriver à une meilleure compréhension de la demande physique générée par des tâches quotidiennes impliquant la technologie afin de déterminer les implications de l'utilisation d'une station active en contexte de travail de bureautique sur la performance.

Plus précisément, il est question de la demande physique directe et la demande physique indirecte et son impact sur la perception et la performance de l'utilisateur d'un artéfact TI. La difficulté d'une tâche est également prise en considération afin de modérer les relations entre les deux types de demandes physiques et la perception/performance des utilisateurs.

Deux expériences ont été nécessaires à l'atteinte de ces objectifs. Tout d'abord, une expérience exploratoire (n=11) a été effectuée en utilisant des instruments captant l'implication du mouvement directe d'une personne lors de tâche de bureautique impliquant un artefact technologique. Cette expérience a permis d'identifier les nombreuses variations possibles du mouvement direct lors de notre travail de bureau. En se basant sur la littérature et les résultats de cette première expérience, une deuxième expérience a été effectuée (n=40) où les effets de la demande physique directe et indirecte ont été mesurés sur la perception de l'utilisateur (données psychométriques) et sa performance (par l'entremise du logiciel EPrime). Le chapitre qui suit fait un rappel des principaux objectifs, présente les résultats des études et leurs contributions puis finalement énonce les limites de la recherche.

3.1 Rappel des questions de recherche

Ce mémoire vise à répondre dans un premier temps à la question suivante :

1. Dans quelle mesure les tâches quotidiennes de technologie de l'information (i.e l'utilisation de la suite Microsoft Office 365) (Okta, 2015) ou encore

l'utilisation d'outils mobiles (tablettes et cellulaires) (Okta, 2015) implique la demande physique directe ?

   a. Quelle tâche TI génère le plus de demandes physiques directes et quelle tâche en génère le moins ?

Une fois cette question répondue, découle la deuxième question de recherche

2. Par cette détermination d'extrême de la demande physique directe d'un type de tâche TI et en considérant également la demande physique indirecte (i.e posture) que génère une station active, quelles sont leurs implications sur la performance d'une tâche TI?
   a. Les hypothèses suivantes sont émises afin de répondre à cette question :
      i. H1 : La demande physique indirecte a un impact sur la perception des utilisateurs de TI.
      ii. H2 : La demande physique directe a un impact sur la perception des utilisateurs de TI.
      iii. H3 : La demande physique indirecte a un impact sur la performance perçue et objective de TI.
      iv. H4 : La demande physique directe a un impact sur la performance perçue et objective de TI.
      v. H5 : La difficulté de la tâche modère la relation entre la demande physique (indirecte et directe) et les perceptions des utilisateurs de TI.
      vi. H6 : La difficulté de la tâche modère la relation entre la demande physique (indirecte et directe) et la performance d'une tâche TI.

3.2 Principaux résultats

Les résultats sont présentés en suivant les questions de recherche ci-dessus.

La première étude vise à déterminer le niveau généré de demande physique directe lorsque l'on effectue une tâche TI. On a pu voir que chacune des tâches génère une vaste quantité de demande physique directe et à différent niveau. De cela, nous avons pu déterminer que l'extrême supérieur de demande physique direct est une tâche nécessitant l'utilisation de l'écran tactile et l'inférieur, une tâche où l'on utilise la souris, et ce pour les tâches assises et debout. Ces résultats ont permis d'utiliser la demande physique directe comme variable indépendante dans l'expérimentation voulant déterminer l'impact de la station active sur le niveau de performance d'un utilisateur de TI.

Afin de simplifier la présentation des résultats de la deuxième étude, ces derniers sont présentés dans l'ordre des hypothèses.

H1 (partiellement supportée) : La demande physique indirecte, soit, dans notre cas, le fait d'être assis ou debout, n'a pas d'impact sur la perception des utilisateurs, dans son ensemble (Stress, Attention, Satisfaction). Cependant, de façon isolée, la composante de la satisfaction est impactée par la position de l'utilisateur. On s'aperçoit qu'il y a une hausse de la satisfaction de ce dernier lorsqu'il effectue une tâche en position debout.

H2 (supportée) : Les résultats suggèrent que plus il y a de demandes physiques directes, plus elle affecte négativement la perception de l'utilisateur. En effet, on remarque que de façon significative, l'utilisation de l'écran tactile qui générait davantage de demande physique directe, impacte les variables Satisfaction et de façon marginale, l'Attention et le Stress.

H3 (partiellement rejetée) : La performance perçue n'est pas affectée par la demande physique indirecte. Un niveau plus élevé de la demande physique indirecte pourrait cependant apporter des avantages à l'utilisation de postes de travail pour certaines tâches. En effet, la demande physique indirecte a eu un effet significatif sur la performance des participants pour la tâche reliée à la mémorisation des séquences de nombres. Cela dit, la demande physique indirecte n'a pas eu d'impact sur d'autres variables de performance des tâches. On peut donc suggérer que le fait d'être en position debout, avec une demande physique indirecte plus élevée, aura des impacts d'amélioration sur les performances dans certaines situations.

H4 : (supportée) : La performance perçue est affectée par la demande physique directe ainsi que la performance objective. Plus il y avait de demande physique directe, plus elle avait un impact négatif et significatif sur toutes les variables de performance (temps de réaction, inverse efficiency score ainsi que les scores de performance (%)).

H5-H6 (supportée) : En comparant une tâche facile et difficile avec des conditions directes et indirectes, on peut conclure que la difficulté de la tâche est significative pour chaque condition. La difficulté de la tâche est un modérateur. La difficulté de la tâche est alors considérée comme un « quasi-modérateur » puisqu'il est également un prédicteur des variables dépendantes. Dans l'ensemble, les résultats suggèrent que la difficulté des tâches modère les relations entre la demande physique indirecte et la perception des utilisateurs (attention, satisfaction et stress) et entre la demande physique directe et la performance (objective et perçue) des utilisateurs.

Quelques autres résultats de cette étude doivent être relevés. En effet, en comparant la position assise et la position debout, pour une tâche facile, on remarque qu'il y a une différence significative pour les variables de la Satisfaction, Number Score (%) et Number IES où il y a une préférence pour la condition en position debout. En ce qui concerne une tâche difficile, la position semble affecter positivement la variable Number Score (%). Pour une tâche facile, les résultats indiquent une meilleure perception et performance lors d'une tâche avec une faible demande physique directe (utilisation de la souris). Par contre pour une tâche plus difficile, seule la performance de la tâche objective est affectée négativement par l'écran tactile (plus grande demande physique directe). Les perceptions des utilisateurs n'ont pas été affectées. Nous pouvons suggérer que le participant se concentre davantage sur la difficulté de la tâche que le mouvement requis par l'écran tactile.

3.3 Contributions de l'étude

3.3.1 Contributions théoriques

Une première contribution théorique est le fait d'avoir exploré la demande physique directe lors de notre interaction avec les technologies. Tel que l'a relevé Elise Labonte-LeMoyne *et al.* (2016), le mouvement qui est généré par le corps humain lors de notre interaction avec les technologies peut affecter la perception des utilisateurs ainsi que leur comportement. Ainsi, il s'agit d'une variable d'importance dans notre interaction humaine machine. Cependant, peu d'études semblent étudier cette notion. La première étude de ce mémoire démontre empiriquement que l'interaction avec les TI génère un vaste spectre de mouvement tout dépendamment du type de tâche effectué ainsi que la position adoptée lors de cette tâche. Cela vient également appuyer un des textes importants de la littérature des stations actives (Straker, Levine et Campbell, 2009) où la variabilité de la demande physique que nécessite une tâche peut engendrer un déclin de performance lors de l'utilisation d'une station active. Ayant ainsi justifié les implications de la demande physique, ce mémoire propose l'un des premiers modèles de recherche s'attaquant au construit de la demande physique en contexte d'utilisation d'une station active et prenant en considération plusieurs variables soulevées dans des études antérieures¸ soit la performance perçue (Commissaris *et al.*, 2014) et objective (Drury *et al.*, 2008; Russell *et al.*, 2016; Sliter et Yuan, 2015), l'attention (E. Labonte-LeMoyne *et al.*, 2015), la satisfaction (Dutta, Walton et Pereira, 2015; Wilks, Mortimer et Nylen, 2006) et le stress (Sliter et Yuan, 2015).

Les résultats de ce mémoire contribuent donc à littérature actuelle en appuyant les notions de la perception des utilisateurs et la performance notamment par le fait que la station active n'altère pas la perception des utilisateurs (Roemmich, 2016) et a peu d'impact sur la performance (Chau *et al.*, 2016; Straker, Levine et Campbell, 2009). Par ailleurs, le deuxième article permet d'appuyer l'hypothèse selon laquelle les bénéfices (positifs ou négatifs) générés par une tâche TI en contexte d'utilisation de station active peuvent s'annuler par la difficulté de la tâche (E. Labonte-LeMoyne *et al.*, 2015)

Cela dit, ce mémoire ajoute à la littérature actuelle le construit de la demande physique. La demande physique directe influence la perception et la performance des utilisateurs. La demande physique directe varie selon le type de tâche. Certains articles antérieurs peuvent se lier à ce sujet (Commissaris *et al.*, 2014; Straker, Levine et Campbell, 2009), mais ces derniers font mention de la précision que nécessite la tâche et non l'ensemble du mouvement requis pour effectuer l'action désirée. En combinant la demande physique directe avec l'aspect de la précision, on développe les notions de notre interaction avec les technologies en contexte de station active, et ce dans l'optique d'optimiser le travail effectué. Sachant que ces postes de travail et leur utilisation par les employés peuvent constituer un défi (Ben-Ner *et al.*, 2014), les recherches proposent des recommandations pour limiter les défis d'implantation de ces postes actifs.

3.3.2 Implications pratiques

En ce qui concerne les implications pour la pratique, dans un premier temps, déterminer quel type de tâche devrait être effectuée sur les postes de travail actifs pourrait améliorer l'adoption. En effet, les résultats empiriques et quantifiables des études présentées permettent aux parties prenantes de faciliter la justification d'un investissement quant à l'achat de station active au sein de l'entreprise. Les articles présentés offrent une vue d'ensemble sur les facteurs pouvant influencer l'utilisateur en contexte d'utilisation de station active. Le gestionnaire pourra justifier sa demande d'achat dépendamment des tâches effectuées par ses employés. Il assurera ainsi un « fit » entre la tâche, l'artefact TI et la station active, ce qui en résultera d'une utilisation optimale de la station active. Ce mémoire permet également de développer la compréhension des gestionnaires à l'égard des enjeux reliés à la sédentarité quant à un travail nécessitant l'utilisation de TI. Une conscientisation face aux risques de santé pouvant causer une décroissance de performance au travail est un premier pas vers un changement à des habitudes plus saines. Le fait qu'il y a que très peu de variation entre les positions debout et assises, tant pour la perception des utilisateurs que leur performance, renforcit l'idée d'instaurer les stations actives à grande échelle. Ayant déconstruit la demande physique de tâche de bureautique, les gestionnaires se trouvent mieux outillés pour recommander l'utilisation de telles stations. Par exemple, ce dernier pourrait suggérer d'effectuer un travail nécessitant moins de demandes directes pour ainsi assurer une utilisation optimale. En promouvant des tâches spécifiques, il est possible de diminuer le temps de mise en œuvre, d'adoption et d'utilisation de ces stations. L'utilisateur est ainsi rassuré quant à sa performance au travail ce qui limite sa résistance au changement d'habitude et lui permettra de mieux gérer l'alternance entre la position assise et debout.

3.4 Limite de l'étude et recherche future

Il faut noter quelques limites aux études qui ont été effectuées dans le cadre de ce mémoire. Les participants étaient principalement des étudiants âgés dans la vingtaine et relativement en bonne condition physique. Cela ne permet pas d'étendre nos résultats sur l'entièreté des utilisateurs d'artefact TI en contexte d'utilisation de station active. En effet, un utilisateur plus âgé pourrait possiblement avoir certaines limites musculo-squelettiques et ainsi avoir un comportement bien différent lors de ses interactions avec la technologie. Afin d'évaluer plusieurs scénarios d'utilisation possible, les participants ont utilisé la station active et la souris/écran tactile pour seulement une courte durée. Cela peut faire varier le niveau de demande physique, tant direct qu'indirect, nécessaire dans un contexte d'utilisation quotidienne. Cette courte exposition à la station active ainsi qu'à un type de tâche avec une demande physique plutôt précise peut générer un effet de nouveauté. Il est ainsi possible qu'une exposition à long terme à la station active, en effectuant tout autre tâche, génère un comportement différent de ce qui a été observé chez l'utilisateur. On pourrait observer une différence dans les résultats au niveau de la perception et de la performance étant donné les expériences antérieures et l'habitude avec l'artefact TI et la station active, ce qui impactera l'interaction.

Les tâches standardisées effectuées par les participants lors de la deuxième collecte de données n'étaient pas totalement représentatives d'une tâche de bureautique quotidienne lors d'interaction avec une technologie. Ce choix avait été fait afin d'assurer la validité de la mesure de la performance des participants. Cependant, il serait souhaitable qu'une étude subséquente valide une mesure de performance similaire à une tâche de bureautique. Cela peut avoir des implications sur certaines valeurs de performance et de perception.

Ce mémoire est une première piste dans la compréhension du rôle de la demande physique lors de l'utilisation de TI en contexte de stations actives. Il ouvre la porte pour des recherches subséquentes qui permettront de renforcir les résultats obtenus lors de cette étude. Les résultats de la deuxième étude ont été recueillis avec une station assise et debout ainsi qu'une tâche impliquant souris et écran tactile. Il serait intéressant de tester le modèle de recherche avec différents types de station active (ex : station avec pédalier, station avec tapis roulant, etc.), mais aussi avec différentes tâches afin d'évaluer si les implications de la demande physique sont constantes à travers différents contextes. Malgré la validation des questionnaires, le contexte expérimental peut jouer sur l'auto-évaluation de la perception des participants. Ainsi, dans une étude subséquente avec des outils neurophysiologiques, il serait possible d'établir des résultats plus représentatifs de la perception des utilisateurs. En effet, ces mesures permettraient d'avoir accès aux émotions de l'utilisateur ce qui renchérirait les données psychométriques utilisées dans la deuxième étude de ce mémoire. Catégoriser les types de tâches avec des aspects tels la créativité, le degré de logique requis, etc. serait pertinent afin de mieux comprendre s'il y a des variations au niveau de la perception et de la performance dépendamment du genre de travail effectué. Finalement, effectuer une étude longitudinale, sur plusieurs mois, évaluant la demande physique indirecte et directe en ciblant le type de tâche effectué par les utilisateurs permettrait de déterminer si les effets de la demande physique se répercutent à long terme.

En conclusion, les réponses aux questions de recherche permettent de justifier l'intérêt de considérer la demande physique dans nos interactions quotidiennes avec les TI. Les variations de cette demande physique impactent la perception et la performance des utilisateurs à différents niveaux. Ainsi, comprendre les tâches de bureautique est une étape essentielle l'adhésion de pratiques de travail plus saine et une diminution des répercussions négatives liées au mode de vie sédentaire.

Bibliographie

Cette bibliographie contient les références ayant servi à la rédaction du chapitre 1 et 3 du mémoire.

Ben-Ner, A., D. J. Hamann, G. Koepp, C. U. Manohar et J. Levine (2014). « Treadmill workstations: The effects of walking while working on physical activity and work performance », *PLoS ONE*, vol. 9 (2) (no pagination), no e88620.

Buckley, J. P., A. Hedge, T. Yates, R. J. Copeland, M. Loosemore, M. Hamer, *et al.* (2015). « The sedentary office: An expert statement on the growing case for change towards better health and productivity », *Br J Sports Med*, vol. 49, no 21, p. 1357-1362.

Botter, Juliane, Rolf P Ellegast, Eva-Maria Burford, Britta Weber, Reinier Könemann et Dianne ACM Commissaris (2016). « Comparison of the postural and physiological effects of two dynamic workstations to conventional sitting and standing workstations », Ergonomics, vol. 59, no 3, p. 449-463.

Chau, J. Y., A. Grunseit, K. Midthjell, J. Holmen, T. L. Holmen, A. E. Bauman, *et al.* (2015). « Sedentary behaviour and risk of mortality from all-causes and cardiometabolic diseases in adults: Evidence from the hunt3 population cohort », *Br J Sports Med*, vol. 49, no 11, p. 737-742.

Chau, J. Y., W. Sukala, K. Fedel, A. Do, L. Engelen, M. Kingham, *et al.* (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 » [Journal: Article], *Preventive Medicine Reports*, vol. 3, p. 68-74.

Commissaris, D. A., R. Konemann, S. Hiemstra-van Mastrigt, E. M. Burford, J. Botter, M. Douwes, *et al.* (2014). « Effects of a standing and three dynamic workstations on computer task performance and cognitive function tests » [Randomized Controlled Trial. Research Support, Non-U.S. Gov't], *Applied ergonomics*, vol. 45, no 6, p. 1570-1578.

Drury, C. G., Y. L. Hsiao, C. Joseph, S. Joshi, J. Lapp et P. R. Pennathur (2008). « Posture and performance: Sitting vs. Standing for security screening », *Ergonomics*, vol. 51, no 3, p. 290-307.

Dutta, N., T. Walton et M. A. Pereira (2015). « Experience of switching from a traditional sitting workstation to a sit-stand workstation in sedentary office workers » [Journal: Article], *Work (Reading, Mass.)*, vol. 52, no 1, p. 83-89.

Karakolis, T. et J. P. Callaghan (2014). « The impact of sit-stand office workstations on worker discomfort and productivity: A review », *Appl Ergon*, vol. 45, no 3, p. 799-806.

Labonte-LeMoyne, E., R. Santhanam, P. M. Leger, F. Courtemanche, M. Fredette et S. Senecal (2015). « The delayed effect of treadmill desk usage on recall and attention » [Article], *Computers in Human Behavior*, vol. 46, p. 1-5.

Labonte-LeMoyne, Elise, Pierre-Majorique Leger, Sylvain Senecal et Radhika Santhanam (2016). « Physical interaction with technology: Kinesiology as a reference discipline for information systems research ».

Levine, J. A. et J. M. Miller (2007). « The energy expenditure of using a "walk-and-work" desk for office workers with obesity », *British Journal of Sports Medicine*, vol. 41, no 9, p. 558-561.

Ohlinger, Christina M, Thelma S Horn, William P Berg et Ronald Howard Cox (2011b). « The effect of active workstation use on measures of cognition, attention, and motor skill », Journal of physical activity and health, vol. 8, no 1, p. 119-125.

Pollack, Keshia M, Gary S Sorock, Martin D Slade, Linda Cantley, Kanta Sircar, Oyebode Taiwo, *et al.* (2007). « Association between body mass index and acute traumatic workplace injury in hourly manufacturing employees », *American journal of epidemiology*, vol. 166, no 2, p. 204-211.

Pronk, N. P., A. S. Katz, M. Lowry et J. R. Payfer (2012). « Reducing occupational sitting time and improving worker health: The take-a-stand project, 2011 », *Preventing chronic disease*, vol. 9, p. E154.

Pronk, N. P., B. Martinson, R. C. Kessler, A. L. Beck, G. E. Simon et P. Wang (2004). « The association between work performance and physical activity, cardiorespiratory fitness, and obesity », *J Occup Environ Med*, vol. 46, no 1, p. 19-25.

Roemmich, J. N. (2016). « Height-adjustable desks: Energy expenditure, liking, and preference of sitting and standing », *J Phys Act Health*, p. 1-20.

Russell, B. A., M. J. Summers, P. J. Tranent, M. A. Palmer, P. D. Cooley et S. J. Pedersen (2016). « A randomised control trial of the cognitive effects of working in a seated as opposed to a standing position in office workers », *Ergonomics*, vol. 59, no 6, p. 737-744.

Sliter, M. et Z. Yuan (2015). « Workout at work: Laboratory test of psychological and performance outcomes of active workstations » [Journal: Article], *Journal of occupational health psychology*, vol. 20, no 2, p. 259-271.

Straker, L., J. Levine et A. Campbell (2009). « The effects of walking and cycling computer workstations on keyboard and mouse performance », *Human factors*, vol. 51, no 6, p. 831-844.

Thorp, A. A., B. A. Kingwell, N. Owen et D. W. Dunstan (2014). « Breaking up workplace sitting time with intermittent standing bouts improves fatigue and musculoskeletal discomfort in overweight/obese office workers » [Controlled Clinical Trial. Research Support, Non-U.S. Gov't], *Occupational and environmental medicine*, vol. 71, no 11, p. 765-771.

Torbeyns, T., S. Bailey, B. de Geus et R. Meeusen (2015). « The use of cycling workstations in public places - an observational study », *Public Health*, vol. 129, no 11, p. 1439-1443.

Wilks, S., M. Mortimer et P. Nylen (2006). « The introduction of sit-stand worktables; aspects of attitudes, compliance and satisfaction » [Article], *Applied Ergonomics*, vol. 37, no 3, p. 359-365.