Determine the Effects of High-Incline Walking on Biomechanical Variables and EMG Patterns on different Treadmill Deck Systems

Rohit Kundu, Taj Krieger, Ricardo Sanchez, & D.E. Lankford

Abstract

While walking at ground and treadmill are common mode of exercise, treadmill walking has gained popularity recently. **Purpose:** The purpose of this study is to determine whether the type of treadmill deck influences surface electromyography (EMG) patterns and impact forces at a high incline (20% grade) compared to a low incline (1%). **Methods:** Physically inactive individuals of 18-59 years will take part in the study. Participants (n=30) will perform two high-incline (20%) walking sessions and two low-incline (1%) exercises on two different treadmills (NordicTrack Commercial X22i and Trackmaster TMX425 Medical Treadmill). EMG markers will be place over the Tibialis Anterior (TS), Soleus (SL), Lateral Gastrocnemius (LG), Biceps Femoris (BF), Gluteus Maximus (GM),Anterior Deltoid (AD), and the Erector Spinae (ES). Trident Inertial Measurement Units (IMU) will be place on the dorsal aspect of the foot (top), mid-point of the shank, mid-point of the thigh, and sacrum (lower back) to measure changes in acceleration (movement) and impact forces.

Introduction

Real World

- Treadmills are the most reliable and efficient way to perform physical activities.
- Better way to control speed and grade, can be used in all weather conditions.
- As per the report of IHRSA Health Club Consumer Report from 2019 treadmill topped the ranking as a popular mode of exercise.

Research World

- Treadmills are the most likely mode of assessment in clinical and research settings.
- Control over speed, grade and surface provides researchers a better control.

Significant Variable

- "Cushioning" is considered a significant difference between different treadmills manufacturers (Nordic, Bowflex, Horizon).
- Running over cushioned deck treadmills was reported to improve leg stiffness by reducing the impact forces. Hence improve the efficiency of running (Kerdok et al., 2002; Shi et al., 2019).

Research Background

- Walking over high-incline reduces the impact forces and increases lower extremity muscle activation, which made it difficult to compare results between different treadmill deck systems (Dixon et al., 2000; Gidley et al., 2020; Haggerty et al., 2014; Lay et al., 2006)

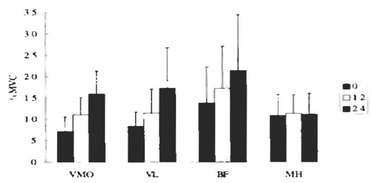


FIGURE 4. *Average electromyographic activity amplitude (%MVC) for the vastus medialis oblique (VMO), vastus lateralis (VL), biceps femoris (BF), and medial hamstrings (MH) during treadmill walking at 0, 12, and 24% grade.*

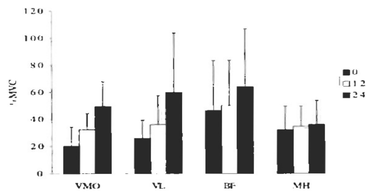


FIGURE 5. *Peak electromyographic activity amplitude (%MVC) for the vastus medialis oblique (VMO), vastus lateralis (VL), biceps femoris (BF), and medial hamstrings (MH) during treadmill walking at 0, 12, and 24% grade.*

- (Lange et al., 1996)

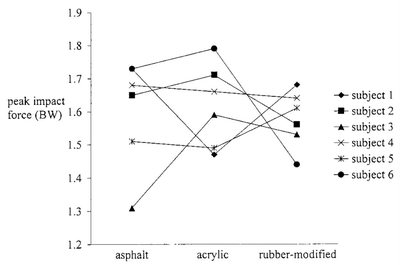
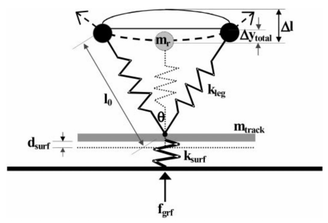


Figure 2—Mean peak impact force over 10 trials for each of the six subjects, for the asphalt surface, the acrylic surface, and the rubber-modified surface.



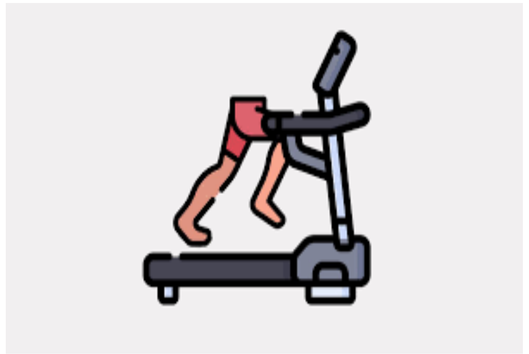
Cal Poly Humboldt.

Research Gap

- Even though multiple studies looked over the impact of surfaces at different inclines in biomechanics (gait, impact forces, tibial acceleration, and muscle activation), still the impact of surfaces has not been examined using different treadmill manufacturers.

Purpose

- The purpose of this study is to determine whether the type of treadmill deck influences surface electromyography (EMG) patterns and impact forces at a high incline (20% grade) compared to a low incline (1%)



Methods

Participants

- 30 participants including Males and Females, 18-59 years, engaged in less than 150 minutes of moderate aerobic physical activity a week or 75 minutes of vigorous-intensity aerobic physical activity, consistently within the past 6 months.

Pre-collection

- All participants will complete the Physical Activity Readiness Questionnaire (PARQ+) and written informed consent before participating in the study.
- Surface EMG electrodes (a simple sticky electrode) will be placed over the shin (Tibialis Anterior), the calf muscle (Soleus), the side of the calf (Lateral Gastrocnemius), the back of the thigh (Biceps Femoris), the upper glute (Gluteus Maximus), Shoulder (Anterior Deltoid), and the side of the spine (Erector Spinae).
- Trident Inertial Measurement Units (IMU, also sticky skin sensors) will be placed on the dorsal aspect of the foot (top), mid-point of the shank, mid-point of the thigh, and sacrum (lower back) to measure changes in acceleration (movement) and impact forces.

MVC protocol

- Participants will be asked to perform three maximum voluntary contractions (MVC) trials for each of the leg muscles being recorded on the right leg.
- An MVC trial consists of contracting the specific muscle as forcefully as possible for a few seconds and obtaining a baseline recording.
- Participants will give a rest period of at least 2-minutes between each MVC trial.

Rating of perceived exertion

- The Borg RPE scale will be used to determine the submaximal speed for both a 20 % incline and a 1% incline.
- As per the Borg RPE scale, 6 is expressed as no exertion at all, and 20 is maximal exertion (Borg, 1982).

Part 1: Determining jogging speed

- Participants will be asked to establish a jogging speed on Trackmaster TMX425 Medical Treadmill, at 1% grade, that they feel they could comfortably maintain for 40-minutes to an hour.
- Rate of perceived exertion (RPE) that is considered "light-moderate" intensity, or an 11 on the BORG 6-20 scale.

Part 2: Jogging test

- Participants will jog on the Trackmaster TMX425 Medical Treadmill at 1% grade at the established speed for 2-minutes.
- EMG and IMU data will be recorded during the last 30-seconds on the treadmill.
- After the participant is done, they will walk a short distance (~20ft) to the NordicTrack Commercial X22i treadmill and begin jogging for 2-minutes at a 1% incline.
- EMG and IMU data will be recorded during the last 30-seconds on the treadmill.
- Participants will fully recover for ~5-10 minutes.

Part 3: Determining walking speed

- Participants will be asked to establish a walking speed on the Trackmaster TMX425 Medical Treadmill at a 20% incline that they feel they could comfortably maintain for 40-minutes to an hour
- Rate of perceived exertion (RPE) that is considered "light-moderate" intensity, or an 11 on the BORG 6-20 scale.
- Participants will then rest for 2-minutes before starting the data-collecting portion of the test.

Part 4: Walking test

- Participants will walk at 20% grade on the Trackmaster TMX425 Medical Treadmill at the established speed for 2-minutes.
- EMG and IMU will be recorded during the last 30-seconds on the treadmill.
- After the participant is done, they will walk a short distance (~20ft) to the NordicTrack Commercial X22i treadmill and begin jogging for 2-minutes at a 20% incline.
- EMG and IMU data will be recorded during the last 30-seconds on the treadmill.

Expectations

- There will be a significant effect of high-incline (20%) walking on muscle activation and tibial acceleration as compared to a low incline (1%).

Significance

- We can gain a better understanding of the impact of treadmill designs on exercise and help inform future treadmills development.
- Will help to select appropriate treadmill for research studies conducting across worlwide.

Citations

- Borg, G. a. V. (1982). Psychophysical bases of perceived exertion. *Medicine & Science in Sports & Exercise*, *14*(5), 377.
- Dixon, S. J., Collop, A. C., & Batt, M. E. (2000). Surface effects on ground reaction forces and lower extremity kinematics in running: *Medicine & Science in Sports & Exercise*, *32*(11), 1919–1926. https://doi.org/10.1097/00005768-200011000-00016
- Gidley, A. D., Lankford, D. E., & Bailey, J. P. (2020). The construction of common treadmills significantly affects biomechanical and metabolic variables. *Journal of Sports Sciences*, *38*(19), 2236–2241. https://doi.org/10.1080/02640414.2020.1776929
- Haggerty, M., Dickin, D. C., Popp, J., & Wang, H. (2014). The influence of incline walking on joint mechanics. *Gait & Posture*, *39*(4), 1017–1021. https://doi.org/10.1016/j.gaitpost.2013.12.027
- Kerdok, A. E., Biewener, A. A., McMahon, T. A., Weyand, P. G., & Herr, H. M. (2002). Energetics and mechanics of human running on surfaces of different stiffnesses. *Journal of Applied Physiology*, *92*(2), 469–478. https://doi.org/10.1152/japplphysiol.01164.2000
- Lange, G. W., Hintermeister, R. A., Schlegel, T., Dillman, C. J., & Steadman, J. R. (1996). Electromyographic and kinematic analysis of graded treadmill walking and the implications for knee rehabilitation. *Journal of Orthopaedic & Sports Physical Therapy*, *23*(5), 294–301.
- Lay, A. N., Hass, C. J., & Gregor, R. J. (2006). The effects of sloped surfaces on locomotion: A kinematic and kinetic analysis. *Journal of Biomechanics*, *39*(9), 1621–1628.
- Shi, H., Li, H., Liu, H., & Yu, B. (2019). Effects of treadmill cushion and running speed on plantar force and metabolic energy consumption in running. *Gait & Posture*, *69*, 79–84. https://doi.org/10.1016/j.gaitpost.2019.01.024