Remote Monitoring Foot Inserts Used to Enhance Sports Performance through Increased Range of Motion

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Abstract

Introduction: The RPM2 device (1) is a wireless, remote monitoring, pressure sensing device used for sports performance enhancement.

Methods: Participants (N=60) reported to the biomechanics laboratory for pre-testing and post-testing, as well as once each week, over a 12-week period, to perform pre-selected exercises programmed into the RPM2 device. The participants inserted the RPM2 device into their shoes prior to testing. Pre and post testing of joint range-of-motion (ROM) was measured by a goniometer, and through video analysis (age 23.10 ± 5.60 years; height 177.34 ± 6.42 cm; body mass 77.39 ± 12.55 kg). The two-mile run was used to assess the aerobic fitness and leg muscles’ endurance.

Results: A significant increase in ROM in the hip, knee, and ankle were found, when using the device and performing the exercises over a period of 12 weeks. ROM increases were observed during hip extension, hip flexion, knee flexion, and in ankle dorsiflexion and plantar flexion (>10 degrees). Adherence to exercise was high, with 95% of subjects.

Conclusion: Data suggest that using the monitoring device may lead to increases in ROM, which translates to an increase in flexibility and force production in the joint. With an increase in ROM, the increased torque produced in a given joint may lead to increases in performance.

Keywords: Shoe insert; Remotely; Phone monitoring; Tele-monitoring; Application

Introduction

The ability to reasonably quantify, predict, and prevent musculoskeletal injuries (MSI) is of significant interest to individuals, clinicians, and practitioners. The prevalence of these types of injuries is significant among athletes, military, and from a clinical perspective to the general public. A perfect mix of muscular control, balance, and proper weight distribution is needed to ensure healthy human gait. Abnormalities and asymmetries in this combination are indicative of existing or emerging issues that can be related to injuries. Technologies that measure these changes in activities and abnormalities in real-time can help in clinical aspects, military operations, and is of significant interest in the athletic community specifically in running assessments.

The purpose of this study is to assess specific technologies that help meet this technology need.

The RPM2 device [1] is a wireless, remote monitoring, pressure sensing device used for sports performance enhancement. The device measures several variables of interest to practitioners and coaches. These variables and the associated data may be used to correct mechanics [2], promote correct form [2,3], prevent injury [2-5], and to speed recovery [3,5]. RPM2 is an insole device that is capable of thermal sensing, measuring body weight, pressure, gait, flexibility and power when cycling [1]. The range of motion in the lower extremities is measured using pressure sensing and accelerometry technology. The purpose of this study was to validate the RPM2 device for commercial/retail use. RPM2 can be used to provide accurate information pertaining to performance of lower extremity mechanics. The device can serve to prevent injury by identifying mechanics that are indicative of injury, and provide information on what needs to be corrected. RPM2 provides measurable evidence, in a readily available format, on an application downloadable and easy to use. This leads to more information for practitioners and coaches improvements and faster attainment of goals.

Methods

Advancing technologies allow remote measurement and monitoring, through applications on smartphones. A novel shoe insert device was evaluated for use in gait analysis. Sensors, embedded in shoe inserts monitor the distribution of pressure on the soles of each foot. A 9-axis sensor is embedded in a microcontroller in each insert, creating a gyroscope. Subjects wore the device while undergoing gait analysis, using the gait analysis plugin component of the Vicon motion analysis system [6]. Joint range-of-motion (ROM) was measured by a goniometer, and through video analysis.
Participants

Subjects were asked to perform recommended exercises while wearing the device, once a week for 12 weeks. Participants included healthy college-age volunteers. Sixty subjects were recruited for voluntary participation in the study. Participants in the study scheduled their appointment with the primary investigator for data collection procedures via phone or electronic communication. Subjects were advised to avoid any exercise or intense physical activity at least four hours before testing. An informed consent form was provided to each participant prior to the testing session, which explained all the procedures and risks associated with participation in this study. A medical history and fitness questionnaire, as well as a Physical activity readiness Questionnaire (Par-Q), were administered to the subjects to determine if they meet the minimum required health and fitness levels to participate in this study. Any participants who answer “yes” to any of the questions featured on the PAR-Q were excluded from participation in this study. Participants were allowed to withdraw from the study at any point in time with no penalty. Participants were divided into active and sedentary groups. The procedures for the study were explained both verbally and in writing prior to beginning the tests [7-13].

Procedures construction

Participants reported to the Biomechanics Laboratory for pre-testing and post-testing, as well as once each week, over a 12-week period, to perform pre-selected exercises programmed into the RPM2 device. The participants inserted the RPM2 device into their shoes prior to testing. Pre and post testing of joint range-of-motion (ROM) was measured by a goniometer, and through video analysis.

Experimental protocols

The subjects were asked to perform a series of flexiblity exercises each week while wearing the device in their shoes. The exercises are standardized by RPM2, and are included in the subject dashboard transmitted to the computer/app by the device. The risks associated with this study were minimal and are not greater than risks ordinarily encountered in a normal supervised rehab or workout program. Participants performed minimal number of repetitions similar to a routine workout. Moreover, a rest period of five minutes was given between each exercise which gave adequate time for muscle recovery. Participants were identifiable on video recordings; however, only numerical identifiers were used to identify participants. No identifiers linking the participants to this study were included in any sort of report that might be published. Video was only used for analysis and was not viewed beyond the investigation. Research records were stored securely in a locked file cabinet and only the primary investigator and co-investigators had access to the records.

Statistical analysis

A repeated measures ANOVA/MANOVA analysed the pre/post test results at each joint, as well as the data reported by the device at each joint vs. the actual measurements obtained by goniometry and video analysis. The research study focused on whether the RPM2 device accurately and reliably measures range of motion in the lower extremities, and stride length and frequency. The device accuracy and reliability in prediction of gait mechanics through body weight distribution, whether the device promotes a change in mechanics in subjects, or promotes adherence to injury prevention exercises were measured. The ability of the RPM2 device to accurately and reliably transmit and record data to a wireless application (as opposed to a wired data collection unit) was tested. The study also investigated whether RPM data provides coaches with information that can be used to change gait and prevent injury. Flexibility/ROM of joints may or may not increase; the validation of the RPM2 device has a significant contribution to the field. RPM2 technology can be used for many purposes in our field related to increasing sports performance through remote monitoring. Statistical significance was set at p<0.05.

Results

No significant differences in pressure distribution or stride frequency or length were found (measured at various phases of gait) between the insert and the laboratory gait analysis (p<0.01). This indicates that the insert can accurately predict pressure distribution at various phases of gait. A significant increase in ROM in the hip, knee, and ankle were found, when using the device and performing the exercises over a period of 12 weeks. ROM increases were observed during hip extension, hip flexion, knee flexion, and in ankle dorsiflexion and plantar flexion (>10 degrees). Adherence to exercise was high, with 95% of subjects completing the study. Table I reports the values and descriptive data.

Conclusion

Data suggest that using the monitoring device may lead to increases in ROM, which translates to an increase in flexibility and force production in the joint. With an increase in ROM, the increased torque produced in a given joint may lead to increases in performance. The ability of the device to reproduce gait analysis can potentially decrease risk of injury, and is a cost-effective way to level the playing field in sports performance. This research may lead to the development of better rehabilitation and preventative programs for athletes, patients, and coaches via the use of remote monitoring. This device provides a novel approach to remote monitoring of athletes.

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