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THE EFFECT OF ARTIFICIAL INTELLIGENCE TO AID IN PHYSICAL THERAPY

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ABSTRACT

Recent years have observed a decline in mobility amongst the global population. With rapid increases in physical diseases, it becomes evident that new methods are required to help combat the decline in physical mobility. The present research seeks to explore if using methods of advanced Artificial Intelligence could aid as a tool in increasing physical mobility for the human body. Specifically, participants were instructed to perform the same exact mobility routine that sought to improve ankle mobility. Half the participants were to do the routine without the use of external programs. The other half were instructed to perform the same routine with the use of AI-powered software that guided users via their webcam. Results showed that participants with the AI software observed a growth rate of 5.89% higher in ankle mobility than the group without access to the AI software. Both groups of males and females observed higher percentages of growth rate in ankle mobility using the software as well. Results ultimately suggest that the use of AI software could become a viable supplement to seek improvement in physical mobility and performance throughout the population.

Introduction

Over the past few decades, global trends have indicated a physical health crisis that pertains to the overall mobility of the human body. By the year 2040 alone, it is expected to see an estimated 78.4 million adults with some form of diagnosed arthritis (Centers for Disease Control and Prevention, 2023). While the numbers are drastic, this should not be shocking, as the majority of adults over 20 nationwide spend 9.5 hours of the day in a stationary sitting position (Medicine & Science in Sports & Exercise, 2021). What is often overlooked, yet could pose an immediate solution, is the implementation of routine physical therapy to help aid in keeping the body mobile.

Artificial intelligence has been seen to aid in identifying and aiding in critical health

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environments, such as surgical procedures. It has also seen a big presence in the fitness realm, with multiple AI and computer vision-powered "coaches" helping users achieve multiple movements such as squatting down to an adequate level. With many of these methods gradually becoming more rooted into modern life by the day, it poses the question if AI can help with other healthcare necessities, such as the aforementioned physical healthcare crisis. The common theme of negligence in physical therapy is the idea of not having enough time or money for the routines developed by quality professionals in the field (Rock Valley Physical Therapy, 2021). As we have seen with many implications of artificial intelligence-based software, AI has allowed users to access many of their most fundamental needs at an extraordinarily efficient rate. Despite technical intelligence growing at a rapid rate, it becomes evident that its independence is currently unreliable. However, its usage as a tool in conjunction with other monitored efforts has worked significantly in the past to help identify important signs such as diseases (Nuffield Council on Bioethics, 2018).

With this, the present study sought to investigate and determine ultimately if artificial intelligence could do similarly and act as a tool in assisting the growth rate of physical therapy. Specifically, the study delves into if people with aided software can develop the growth rate of their ankle mobility faster than those solely dependent on traditional methods. If so, it could be suggested that AI-based software can pose an instrument in assessing and improving physical therapy needs for the common people.

Methods

Participants

16 participants (8 males and 8 females) were selected from Northern Virginia high schools. Participants were divided into two groups, with each group having 4 males and 4 females. Each participant's height, weight, and previous major injuries (if any) were recorded.

The Software

In assessing and stimulating the growth of ankle mobility, participants using the software were given access to an application that utilized their webcams to display a pathing projected onto the body for the users to follow. In order for this pathing to be displayed, the software must be able to calculate the angle measurement formed by the ankle while the leg is in a forward bent position, otherwise known as the angle of dorsiflexion of the ankle. MediaPipe is an open-source framework that allows us to isolate specific points of the body into sectors specifically. The software uses MediaPipes landmark mapping, which labels 33 key landmarks of the body and a value (0-32) representing the landmark. For instance, the right knee would be represented by the value 26, and the left knee would be represented by the value 25. What this allows for is access

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to the specific coordinates on the webcam where these body parts are represented. To do so, an array must be defined where the value of these landmarks can be utilized. MediaPipe allows this efficiently with the line: landmark = results.pose_landmarks.landmark. This sets the variable landmark to an array of detected key coordinate points. By inputting the respective values of the landmarks on the body (0-32) into the array, we get access to the x, y, and z coordinates of the landmark on the webcam. In this case, to calculate the angle formed by an ankle in dorsiflexion, 6 landmark values are needed: Left ankle, right ankle, left knee, right knee, left toe, and right toe.

To get their actual values (0-32), a built-in MediaPipe function can be used. For example, "mp_pose.PoseLandmark.LEFT_ANKLE.value" would return the corresponding value for the left hip landmark on the body, in this case being the number 27. This value can then be used in the array defined earlier to allow access to the respective coordinate points for the landmark. In this case, to get the x, y, and z coordinates of the left hip the following line would be used: landmark[mp_pose.PoseLandmark.LEFT_ANKLE.value]. This would be done for all 6 of the landmarks needed for both legs of the body. With the help of NumPy's "np.array" and "np.arctan2" functions, the software stores these coordinate pairs in arrays and is then able to use these x and y coordinates to calculate the proper angle measurement formed by the hip, knee, and ankle using trigonometry.

As the leg in sight of the webcam bends, the angle measurement calculated by the software decreases in real-time. The goal of increasing ankle mobility is to allow the body to decrease the angle of dorsiflexion while the foot is stationary on the ground and the leg bends forward. As such the software is able to create a standard for a degree of dorsiflexion that the body must be able to perform to be counted as a successful bend. Once the ankle in front of the webcam reaches an angle of dorsiflexion at the standard or lower, the display projected onto the webcam would change colors while the number of exercise repetitions indicated on the side of the webcam would increase by one. For example, in the first week of trials, the angle standard angle was 35 degrees. Once the participant booted up the software and bent their leg to meet the 35-degree mark indicated by the software, the display would change from blue to the color red, as well as their repetition counter increasing from zero to one.

Procedure

Prior to experimentation, participants were to take initial measurements of their bent leg distance in the same manner as the measurements they would take during the 4-week experimental period. Once collected, participants were split into two test groups, with one accessing the guided software.

Participants were then provided with the instructions as well as the expected routine they were to

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follow. Both test groups were given the same exact ankle mobility exercise and routine. The routine indicated for both groups to have the right foot flat on the ground while the left foot laid back into a lunge position. Then, they were to bend the right leg forward into a position where the angle formed by the knee, ankle, and toes met the standards for the angle for that week. The standards for the angle of the first week were 35 degrees and would decrease by increments of 5 degrees over a 4-week experimental period. Once the bend of the ankle met the standard, Participants were instructed to hold the position for 5 seconds. Both test groups were instructed to repeat this motion followed by a hold for 10 repetitions. They were to perform 3 sets of these 10 repetitions in one session, performing 3 sessions per week during the 4-week period. These sessions were on Monday, Wednesday, and Friday. For adequate results, Participants of both groups were instructed to perform their sessions of mobility work in the morning anytime before 12 pm, after which they could go on with their day as they pleased.

Over the course of the four weeks, the experimenter took measurements of the Participants at the end of each week to gauge the growth of their ankle mobility as well as to be used in the final results. The dependent variable to be measured was the horizontal distance from the back of the heel to the front of the knee of the right leg in its most bent position. To do so, participants were instructed to keep their right foot flat on the ground in a lunge position similar to the position of the given mobility exercise. Only this time, they were told to bend their right leg forward to achieve its max distance horizontally. Then, a wooden plank was placed vertically against the front of their knee, aligning perpendicular to the ground. Once positioned, a measuring tape was used to measure the length from the back of the participants' heel to the edge of the wooden plank (the same side that met the knee), and the number (in inches) was recorded.

Measurements to analyze the growth of ankle mobility within participants were taken on the Saturday of each week during testing. These were performed and done in the afternoon. After all the measurements were taken, participants of both groups were informed of the new angle standard they would have to meet in their sessions the following week (5-degree decrease), and the test group with the software was given an updated version that implemented the new angle standard for the following week.

Results

Compared to the 8 participants without access to the software, participants with the software achieved higher overall growth both weekly and in comparing final measurements to initial measurements. When comparing final measurements to the initial, participants using the software observed an average percentage increase of 16.17% and an average inch increase of 2.76 inches over the 4-week period, with around 4.04% of growth per week, whereas participants without access to the software saw an average percentage increase of 10.28% and an average

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inch increase of 1.53 inches over the course of the 4 weeks, with around 2.57% of growth per week. The difference in inch increase for the group with software access versus those without was significantly different, $t = 2.13$, $df = 15$, $p = 0.007$.

Figure 1: Results from Participants with Access to the AI Software (Note: T stands for test group)

With AI Software	Start	End (4 weeks)	Percentage increase	Inch Increase
#1 M T	17.1	20.3	18.7135	3.2
#2 M T	18.4	21.3	15.7609	2.9
#5 F T	15.6	19.7	26.2821	4.1
#6 F T	14.8	17.7	19.5946	2.9
#8 M T	21.4	24	12.1495	2.6
#9 M T	21	23.3	10.9524	2.3
#14 F T	17.4	19.9	14.3678	2.5
#15 F T	13.9	15.5	11.5108	1.6
Average	17.45	20.21	16.16645	2.7625

Figure 2: Results from Participants without Access to the AI Software

	Start	End (4 weeks)	Percentage Increase	Inch Increase
#3 F	16.9	19.3	14.2012	2.4
#4 M	17.3	19.8	14.4509	2.5
#7 F	15.8	16.7	5.6962	0.9
#10 F	13.8	16.4	18.8406	2.6
#11 M	20	20.9	4.5	0.9
#12 M	15.9	17	6.91824	1.1
#13 M	18.7	19.7	5.34759	1
#16 F	13.4	14.2	5.97015	0.8
Average	16.47	18	9.49061	1.525

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Males saw a much higher growth rate in ankle mobility with the software, with the growth in percentage for men over the 4-week period being almost double with the software versus without. The male software group observed a 14.39% increase in length over the course of 4 weeks, whereas the males without access to the software only reported a 7.80% increase. Of all the males in the group without software access, only one exceeded a growth greater than 2 inches, with the average growth in inches for their group being 1.38 over the course of 4 weeks. In contrast, the male group with software access all exceeded a 2-inch growth mark over the 4-week period, with an average increase of 2.75 inches, $t = 1.895$, $df = 7$, $p = 0.003$.

Females also saw a higher growth rate in ankle mobility while utilizing the software. The female group with the software observed a 17.94% increase in ankle mobility length after the 4-week period, compared to the 12.76% that the group without the software observed. One female using the software also observed the highest growth in inches throughout all 16 participants, with an increase of 4.1 inches. All females using the software had an increase of over 1 inch, with 3 ofthe 4 having an increase of over 2 inches. In contrast, half of the female participants without software access did not see an increase of over 1 inch, $t = 1.895$, $df = 7$, $p = 0.04$.

Discussion

The primary purpose of the research conducted was to determine the overall effectiveness of an artificial intelligence-based computer vision software in aiding to benefit previous traditional forms of improving ankle mobility. The overall result was deemed to be that participants aided by the artificial intelligence software were able to observe a significantly higher growth rate in their ankle mobility over a 4-week period versus those solely using traditional methods.

Specifically, participants using the software experienced a 16.17% growth rate in their mobility as opposed to the other groups' 10.28% growth rate. While both males and females overall significantly benefited from the use of the software, males specifically seemed to achieve twice as much of a growth rate using the software than without. It is important to note that external factors could have also stimulated or hindered mobility growth for either group. No participants reported any injuries during experimentation. However, a post-research survey revealed that 3 participants (1 in the software group, and 2 in the traditional group) did engage in recreational activities involving physical movements such as basketball and volleyball. Since these movements demand a high degree of ankle mobility, the expected result for these participants was to have a higher growth percentage compared to the other participants. However, both participants in the traditional group that reported engaging in recreational activity did not reach a growth percentage of above 7%, and the participant in the software group that reported engaging in physical activity had the third lowest percentage increase, which further supports the validity of the results collected.

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Seen as the AI software used during research was not in complete control over the entire mobility program in use, more so as assistance to gauge the form of the movement performed, our findings suggest that AI as a whole can pose to be a highly functional tool to help aid in increasing mobility based on preprogrammed regimes and exercises. On an even grander scale, we can see the methods of AI in the world of physical therapy being used in conjunction with doctors and physical therapists themselves as a way to scale the growth of their clientele and ensure that the methods their patients use in the off time are more accurate and easily trackable, thus promoting a much faster and measurable growth rate in their physical capabilities. We can also see this being used for those who perhaps are unable to have access to quality physical therapy and physical healthcare locally. While not completely replaceable to quality healthcare, the software if expanded on could very easily help aid those less fortunate to create a much healthier foundation for their body. Another key implication of these methods is considering that much of the present-day population finds themselves in predicaments of stationary positions for long durations. Simply allowing easily accessible programs in the form of AI software would hope to increase the mobility of much larger populations.

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