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Validation of Speed and Stride on the Uniport Mobility Platform

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13. ABSTRACT *(Maximum 200 words)*

Three studies at the Human Research and Engineering Directorate of the U.S. Army Research Laboratory were performed to validate that a person travels at the same speed on the Uniport mobility platform as he or she would in real life. The Uniport consists of a unicycle type mobility platform, which allows a person to "pedal" his or her way through the virtual environment. The first study involved having an individual walk, jog, and run in both settings. Different wheel gain settings within the software were used during the virtual part of the study. The wheel gain is the ratio between the average individual's stride length and one pedal rotation on the Uniport. Data that were collected included time and strides over a known distance. The second study was conducted to validate that the digital speedometer displayed on the monitor was correct. Individuals were told to travel at a particular speed on the speedometer and travel a known distance in the virtual environment. Time of travel was recorded and compared to the actual time that it would take to travel at that known speed and distance. The third study combined the information obtained and some techniques from the first two studies to determine what the wheel gain settings were needed to correlate strides and speed between the real and virtual environments.

The results of these studies show that a wheel gain setting of 1.5 is to be used when a person is walking in the virtual environment. A wheel gain setting of 3.0 is to be used when the individual is jogging or running in the virtual environment. The validation of the digital speedometer was confirmed and will play an important role in future research of the Uniport.

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BACKGROUND

Modern simulation technology has been proved to be a fundamental element in maintaining readiness for war. It provides soldiers with skills and techniques that are transferable to battlefield conditions. In 1973, the Army began conducting evaluations comparing its customary classroom or "theoretical" training with tactical engagement simulation using emulators of direct fire weapons. Supported by favorable reports from these evaluations, the Army adopted the multiple integrated laser engagement system (MILES) in the late 1970s and set up the National Training Center at Fort Irwin, California, for battalion-size force-on-force simulation. Results show that soldiers faced with capable opposing forces improved individual survival skills and tactical teamwork skills (Gorman & McMaster, 1992).

Spurred by this success story, the Army joined with the Defense Advanced Research Projects Agency in the Simulation Network Project (SIMNET) to demonstrate the technological feasibility of conducting tactical engagement simulation with a large scale, geographically distributed network of simulators on a "virtual" computer-generated battlefield. In 1990, the Army conducted a test using nine tank platoons and nine mechanized infantry platoons. The test was designed to evaluate the effectiveness of SIMNET-like simulators for training troops in combat-relevant tasks and whether to continue with development and procurement of the close combat tactical trainer (CCTT). Training for each unit was assessed during tactical engagement simulation. Unit performance was determined by scoring a number of tasks and subtasks. These scores served as pre-training ratings. The platoons then trained for 3 days with SIMNET. The platoons were evaluated on the computer using tactical engagement simulation, deriving post-training ratings. The results showed improvements in platoon performance of subtask standards after SIMNET training (Gorman & McMaster, 1992).

One implication of modern simulation technologies is their usefulness in training commanders and staff personnel, as well as tankers and infantrymen. One of the most recent developments in simulation technology to aid the infantry soldier is the Uniport, the first phase of the I-Port program or "Individual Soldier's Portal into the Synthetic Environment," developed for the U.S. Army Research Laboratory by SARCOS Research Corporation and the University of Utah's Center for Engineering Design. The Uniport is an electro-mechanical device that functions as an individual combat simulator (ICS) specifically for the "electronic battlefield."

Uniport (see Figure 1) consists of a unicycle type mobility platform which allows the soldier to "pedal" his or her way through the virtual environment. The real-time virtual environment is provided through the Naval Postgraduate School and Network (NPSNET). It is designed to extract energy by exerting a metabolic load on the soldier that is commensurate with his or her rate of movement on the simulated terrain. A helmet-mounted display (HMD) allows the soldier to see the terrain and environment with which he or she will be interacting. A model M-16 rifle provides target training against opposing forces. Uniport allows an individual to move, shoot, and interact with all other objects on the battlefield within sight, hearing, or range of his or her weapon. A future version of the I-Port mobility platform will allow the soldier a more natural walking motion when traversing the virtual terrain.

To make the Uniport device as realistic as possible, it will be necessary for the user to experience physical exertion similar to that felt during an actual situation. Kinesthesia, providing for a person's sense of moving and performing work, is one major determinant of validity of the Uniport device. For example, if the task requires climbing a hill, Uniport should replicate the task and its environment, thus evoking similar human performance with regard to energy expenditure and movement time.

OBJECTIVE

The validity of speed and energy expenditure of an individual using the Uniport simulator as opposed to regular travel on foot was the emphasis behind this research. This report discusses the study and outcome of comparing speeds and strides of an individual on the Uniport and on a real running track. The results from these experiments were used to conduct a subsequent study for monitoring energy expenditure on the Uniport.

PROCEDURE

Three studies were performed to validate that a person travels at the same speed on the Uniport, within the virtual environment, as he or she would in real life. The first study involved having an individual walk, jog, and run in both settings. Data that were collected included time and strides over a known distance. The second study was conducted to validate that the digital speedometer displayed on the monitor was correct. Individuals were told to travel at a particular speed on the speedometer and travel a known distance in the virtual environment. Time of travel was recorded and compared to the actual time that it would take to travel at that known speed and distance. The third study combined the information obtained and some techniques from the first two studies to determine what the ratio settings of pedal movement to distance traveled were needed to correlate strides and speed between the real and virtual environments.

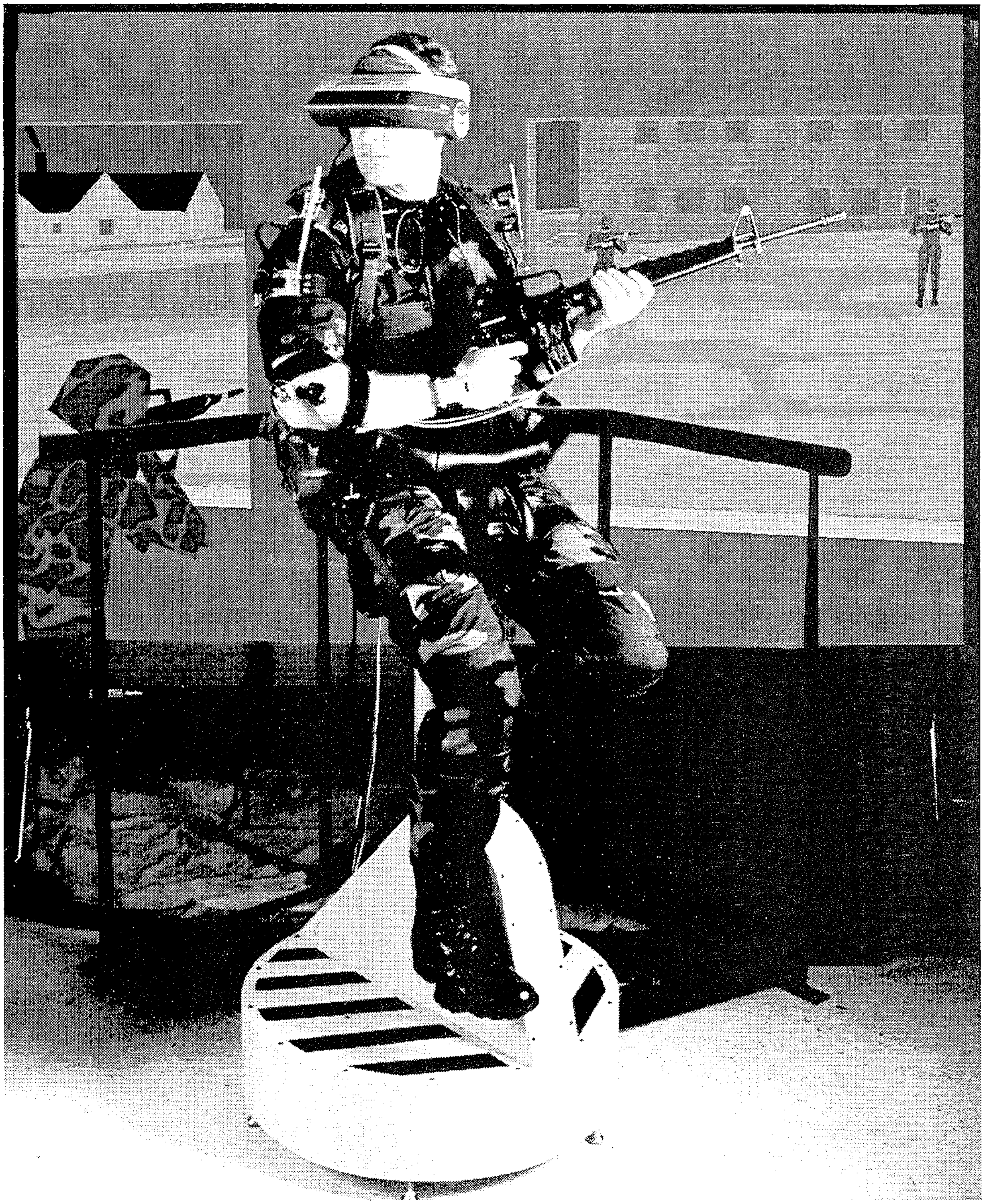

Figure 1. Uniport in a walk-in synthetic environment (WISE).

Speed and Stride

The first study was a comparison of a person's time and number of strides needed to complete both a virtual 100-m track and a real 100-m track. The data from each were compared to determine if the current gain settings within the Uniport software were set so that the results from each were nearly the same. The study began by using the virtual track before the real track because this was the first time for any type of comparison on the Uniport that examined its virtual representation of speed and stride. It was not known if the results would even be close to being realistic. For the first attempt, only one person was used for comparison. If the Uniport results had not been comparable to an individual's actual speed at the various paces, then more individuals may have been used and possible software adjustments would have been made to make it comparable.

A 100-m track model that was graduated into 10-m increments and the "Jack" (Badler, Phillips, & Webber, 1993) icon (a representation of the individual in the virtual environment) viewed on a video monitor were the main tools used for measuring the individuals' progress while they walked, jogged, or ran the virtual course seen in Figure 2. As the individual proceeded (see Figure 3), observers monitored (a) the time of travel of the Jack icon at each 10-m increment, (b) the icon's stride, and (c) the number of rotations needed to pedal the Uniport for 100 m. A video camera was used to record the pedal rotations so that an accurate number of rotations could be manually counted upon viewing the video.

The results were recorded at all three paces for a wheel gain setting of 1.5. The wheel gain setting is used to correlate the pedal rotations with the movement of the individual in the virtual environment. The setting is the ratio between the average individual's stride length and one rotation on the Uniport. By rotating the pedals and watching the stride of the Jack icon, the authors found that a wheel gain of 1.5 provided the best correlation between the Jack icon and the Uniport for walking in the virtual environment. Initially, this proved to be too small of a setting for jogging and running, based on the observation that the Jack's speed and stride changed very little in comparison between the three paces at a wheel gain of 1.5. The process was then duplicated using a wheel gain setting of 3.0. The results for both wheel gains are presented in Table 1.

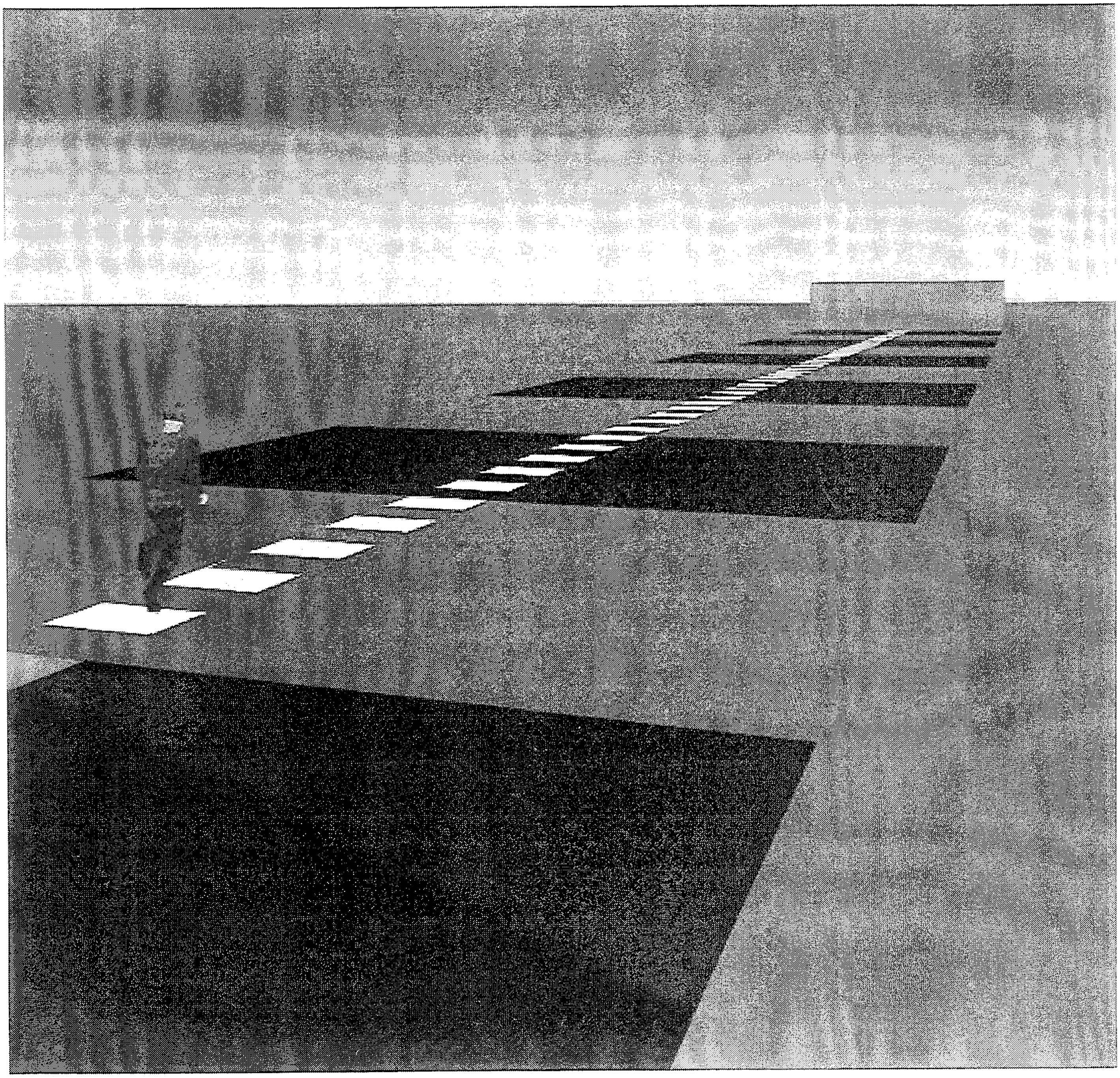

Figure 2. Jack on the virtual 100-m track.

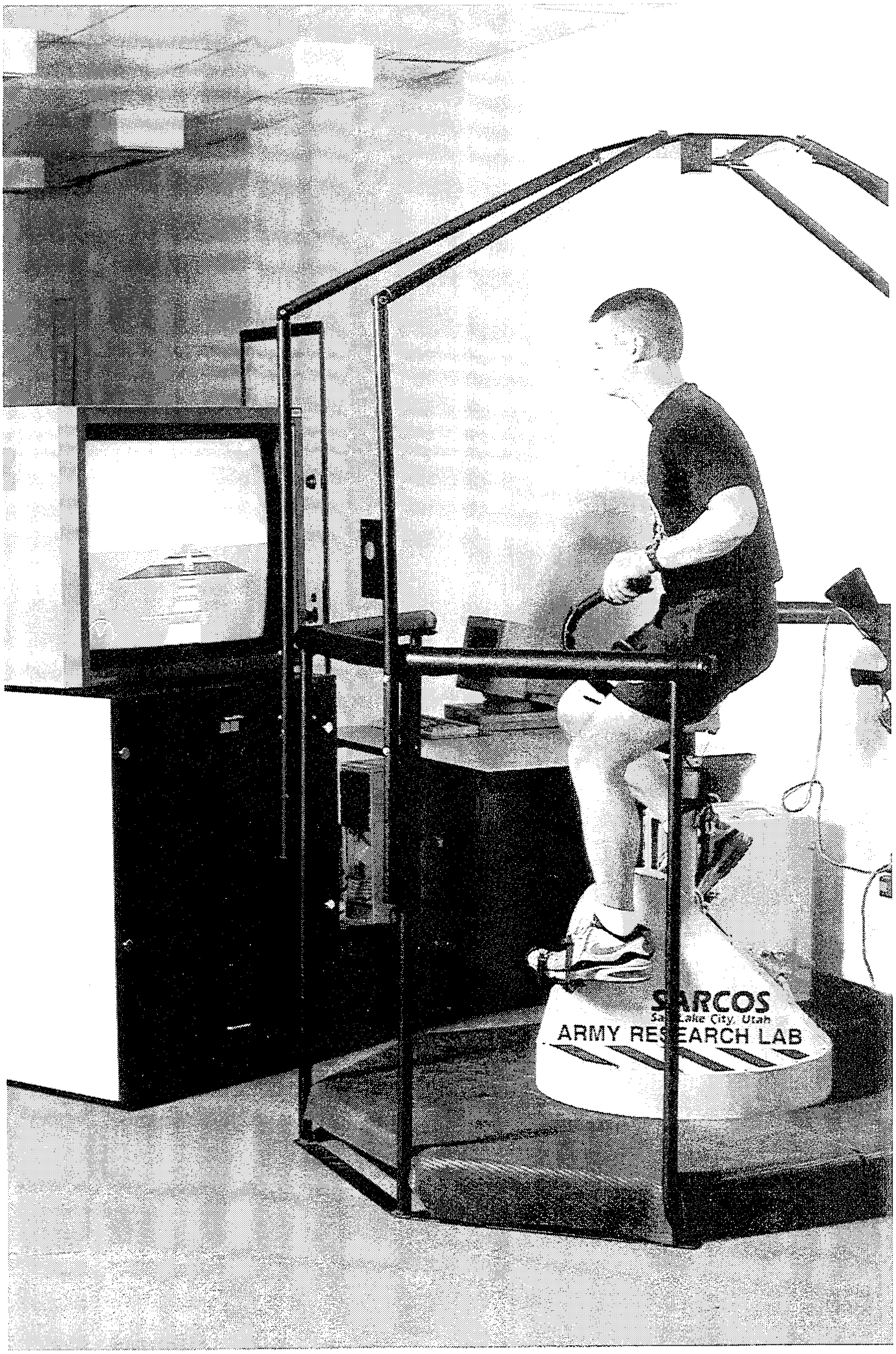

Figure 3. Individual on the uniport traveling on the 100-m track.

Table 1

Uniport 100-m Test

Distance (meters)	Wheel Gain = 1.5 Jog (seconds)	Run (seconds)	Walk (seconds)	Wheel Gain = 3.0 (seconds) Jog (seconds)	Run (seconds)
10 m	5	5	7	3	2
20 m	8	9	14	5	4
30 m	11	11	21	7	5
40 m	15	15	27	9	7
50 m	19	19	34	11	8
60 m	22	23	41	14	10
70 m	26	27	47	16	12
80 m	30	30	53	18	15
90 m	33	34	59	20	-
100 m	37	38	66	22	18
Speed (mph)	6.0	6.0	3.4	10.2	12.4
Rotations (rev.)	63	92	59	31	47

The second part of the study was the data collection of an individual walking, jogging, and running on a real 100-m course. Two parameters were recorded as the individual completed the course for each pace: 1) total time and 2) number of strides over the 100 m. Table 2 shows the results of three paces on the real 100-m track.

Speed

A second study was performed as a means of verifying that the newly added speedometer on the virtual display showed the correct speed at which an individual was traveling on the Uniport using a wheel gain of 1.5. The speedometer was not available during the first study but was found necessary to determine wheel gains for jogging and running. The setup for this study was the same as for the first part of the previous study. The speed was displayed on the monitor that displayed the virtual track. Three individuals were asked to pedal the Uniport along the virtual 100-m track five different times. Each time they were asked to travel at constant but different speeds ranging from 2.0 to 4.0 mph at increments of 0.5 mph. A metronome was used to aid the person in maintaining a constant speed. Each metronome setting was a pre-established rate of beats for a particular speed. The individual pedaled to the beat of the metronome to maintain constant rotation of pedals. One beat represented one full rotation of the pedals. The individuals were then timed for the 100 m at each speed. The times were compared with the time it should take to travel a real 100-m track at the corresponding speed. Table 3 shows each person's results and his or her average compared to the actual time necessary to complete 100 m for each speed.

Table 2

Real 100-m Test

Pace	Time (seconds)	Stride (steps)	Speed (mph)
Walk	73.06	127	3.1
Walk	70.92	125	3.2
Jog	23.52	-	9.5
Jog	23.32	62	9.6
Run	13.79	63	16.2
Run	13.54	-	16.5

Table 3

Times Recorded to Travel a Virtual 100-m Track at Various Speeds

	2.0 mph	2.5 mph	3.0 mph	3.5 mph	4.0 mph
Subject 1	114.6 s	87.1 s	75.7 s	68.0 s	56.9 s
Subject 2	117.3 s	89.3 s	75.5 s	64.5 s	56.1 s
Subject 3	113.9 s	92.2 s	75	65.6 s	59.2 s
Average	115.3 s	89.5 s	75.4 s	66.0 s	57.4 s
Actual time	112.0 s	89.0 s	75.0 s	64.0 s	56.0 s

Wheel Gain and Stride

Results from the first study confirmed that as the wheel gain was varied, the number of pedal rotations needed to complete the 100-m course varied. The addition of a speedometer provided a means to maintain a constant speed so the wheel gain could be varied and an accurate time and stride could be measured. This third study used the speeds gathered from the real 100-m jog and run (see Table 2). Speeds of 9.5 (jog) and 16.5 (run) mph were selected for a person to travel on the Uniport. Wheel gains of 3.0, 3.5, and 4.0 were used to observe the effects of time of travel on the virtual 100-m course and the number of pedal rotations. The pedal rotations were video recorded to ensure an accurate count.

RESULTS AND CONCLUSIONS

In the first study, a direct comparison between the jogging and running speeds of the real and virtual environments was not possible without a speedometer on the Uniport. Initially, the test subject was told to pedal at the same rate as he felt he would be doing on a real track. The results show that guessing the speed of travel was not exact; however, it was comparable enough to determine that a wheel gain of 1.5 was not large enough for any pace faster than walking, based on the measured speed and stride. A wheel gain was desired that produced the same speed with the same number of strides for both environments. For this initial testing, one 360° rotation was expected to represent two steps in real world even though stride length varies from person to person. When a wheel gain of 3.0 was used, the speeds and strides appeared to be more comparable to the real track results, but the addition of a speedometer was needed to determine if 3.0 was indeed a valid number. This first study validated that the wheel gain of 1.5 was suitable for walking in the virtual environment. Table 1 shows that the speeds were comparable as were the strides.

The second study was necessary in order to do a valid test in the third study. The addition of the speedometer allowed a person to travel at a known and constant speed so that other variables could be measured. The results from Table 2 show a close relationship between the measured and actual times. The slight differences between the calculated and average measured data are attributed to two main factors: (1) the individuals could not always maintain a constant speed even though the metronome was an effective aid; (2) an occasional network interface problem that momentarily affected the communication between Uniport and the virtual environment software resulted in a sudden and brief change in speed. This is considered to be a minimal problem. Overall, the speedometer is valid for all speeds at any wheel gain.

The final study was the completion of the first study. When the speeds were held constant at 9.5 and 16.5 mph, the time and strides measured over the length of the virtual course could be directly compared to the measured time and strides of the real track. In Table 4, wheel gain values of 3.0, 3.5, 4.0 were compared for the jog and the run. The measurement taken for a wheel gain of 3.0 shows a very close comparison for the time and strides for the jog and run (one rotation is considered to be two steps). The difference in time between the real and virtual run was larger than the jog; however, the difference can be attributed to the same effects discussed for the second study, constant speed and computer interface delays. Further studies should be done to determine the wheel gains for different sized individuals to match their real stride with the virtual. Until more research can be done, the recommended wheel gain setting for jogging and running will be 3.0.

Table 4

Speed and Stride Comparisons

	Wheel Gain = 3.0		Wheel Gain = 3.5		Wheel Gain = 4.0	
	Time (s)	Stride	Time (s)	Stride	Time (s)	Stride
Actual jog*	23.5	62 steps	23.5	62 steps	23.5	62 steps
Uniport jog	23.7	32 rot.**	24.4	23 rot.**	24.1	25 rot.**
Actual run*	13.6	63 steps	13.6	63 steps	13.6	63 steps
Uniport run	12.8	32 rot.**	14.2	23 rot.**	12. 9	24 rot.**

* Data collected from first study

** rot. = one 360° rotation

REFERENCES

Badler, N., Phillips, C., & Webber, B. (1993). Simulating humans: Computer graphics, animation, and control. Oxford: Oxford University Press.

Gorman, P.F., & McMaster, H.R. (1992). The future of the armed services--training for the 21st century (statement before the Senate Armed Services Committee). Washington, DC: Authors.

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