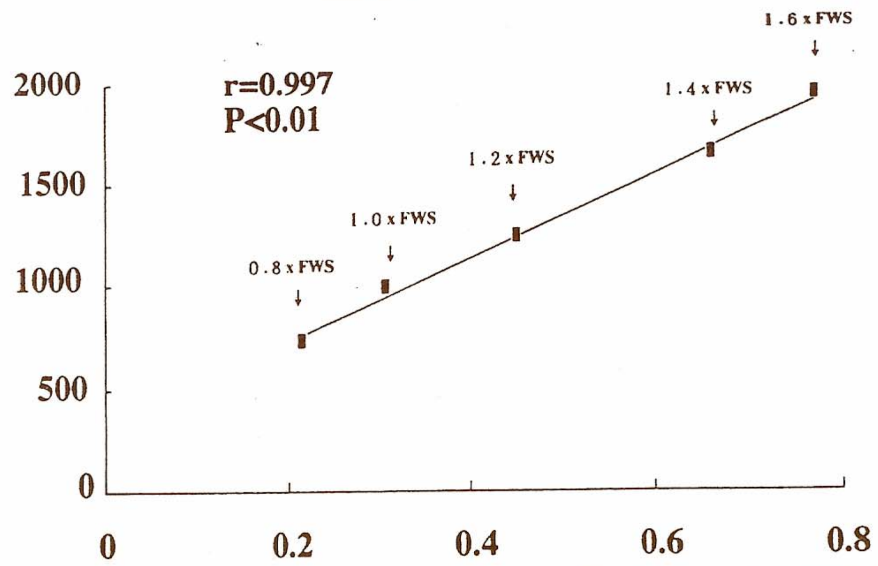

ngle correlation chart for case 4. Examination of relationship between PCI and oxygen uptake in response to walking speed gives a significant correlation between the two (r=0.997, p<0.01).

ion

ıim of the study was to investigate or not PCI is applicable as an indicator ıitoring the amount of exercise load d in walking with an Intelligent ;is. PCI is one of the cardiopulmonary which combine the elements of HR and ; speed, suggested by MacGregor egor, 1979; MacGregor, 1981). Steven 983) have reported that PCI is effective ıg the efficacy of medication on patients eumatoid arthritis. Butler *et al.* (1984) trated that in a comparison of PCI ı children with impaired walking and . with normal walking, the PCI is a useful r for the diagnosis of walking. Nene and s (1992) measured the PCI of patients inal cord injury walking with the aid of LAU ParaWalker and found it useful in son with other movement measurement s. In Japan, Wada *et al.* (1993) have d a significant correlation between PCI lking energy consumption in patients g from osteoarthritis of the coxa. Thus known as an indicator for evaluation of efficiency.

ell known that for lower limb amputees, arly trans-femoral amputees, the energy prosthesis is high (Gonzalez *et al.*, 1974; Waters *et al.*, 1976). The characteristics of an Intelligent Prosthesis may allow a higher walking speed than with conventionally damped prostheses (Zahedi, 1993). In this circumstance the energy consumed in walking would be higher and the burden on the cardiopulmonary function greater. It is therefore important to ascertain accurately the exercise load involved in walking with an Intelligent Prosthesis to provide safety in its use. The best means of accurately ascertaining the exercise load is to directly measure oxygen uptake. However, it is not easy to measure this directly due to the complexity and awkwardness of the equipment and measurement technique. Furthermore, it is not possible to make direct measurement during prosthetic walking training in the ordinary place of rehabilitation. Therefore in place of oxygen uptake a simple objective indicator which will allow the estimation of exercise load is required.

In this research the energy consumption of walking with an intelligent prosthesis was measured by oxygen uptake at a wide range of walking speeds and the relationship with PCI was investigated. In each case it was observed that an increase in walking speed was accompanied by a tendency toward increased

case there was a significant correlation between PCI and oxygen uptake as they varied with walking speed, which indicates a close relationship between cardiopulmonary factor and energy consumption factor while walking. PCI can be measured easily in a clinical environment while it makes it potentially useful as an indicator for ascertaining the amount of exercise load involved in walking with an Intelligent Prosthesis and monitoring the cardiopulmonary function under exercise load.

Conclusion

The applicability of PCI measurement as an indicator for monitoring the amount of exercise load involved in walking with an Intelligent Prosthesis has been established. This study indicated the feasibility of the clinical application of PCI in Intelligent Prosthesis walking training for amputees.

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its use. The fit of prosthesis was reviewed by certified prosthetists. djustment of the Intelligent knee joint nputee was carried out by certified erapists. The physical characteristics ects are shown in Table 1.

ıost comfortable walking speed for t using an Intelligent Prosthesis, i.e. evel walking speed (FWS), was prior to testing. HR at rest was ter the subject had been seated for 15 aboratory environmental conditions olled at a temperature between 20°C and relative humidity at 60%. vritten consent was obtained before he study. In this research a treadmill The exercise protocol was as follows: bject after 5 minutes of warm-up at the subject's FWS, the speed was ontinuously in steps every 5 minutes nes the subject's FWS until the speed was achieved. The treadmill vel for the duration of testing. During e respiratory gas was monitored with ıonitor (Minato RM-300 system, ın) on a breath by breath basis. At the the ECG and HR were monitored rcise by Stress Test System (ML- da Denshi, Tokyo, Japan), and cuff sure was determined every minute toelectrocardiometer (Colin STPB-). Treadmill walking is used in the Prosthesis walking training and it was the subjects were skilled in its use. ly the measurements were taken only guard against falling during nt the subjects were allowed to

Physical characteristics of the subjects

	1	2	3	4	5	6
	F	M	M	M	M	M
	19	23	20	26	34	17
	47.8	66.0	57.0	64.0	70.0	58.5
	168	175	172	176	170	176
	T	T	T	T	T	T
aid	no	no	no	no	no	no
)	4.0	4.5	4.0	3.5	3.0	4.0

ree level walking speed T: trauma

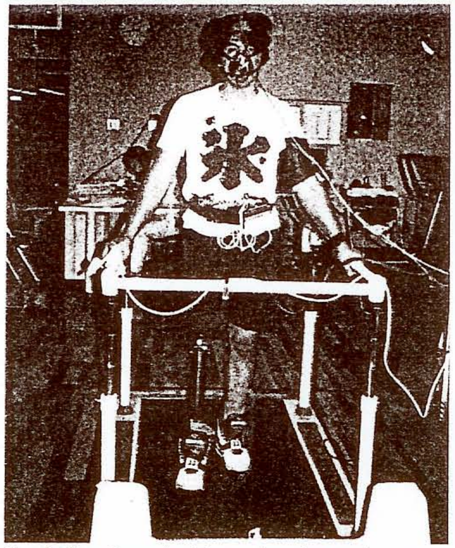

Fig. 1. Experimental subject undergoing respiratory gas analysis. Subject is instructed to hold the support bar lightly with both hands to avoid the danger of falling during measurement.

lightly grip a support bar in both hands, but they were directed not to grip strongly (Fig. 1). The parameters during the last 2 minutes of the 5 minutes of each exercise stage were averaged. PCI was calculated as (HR while walking – HR at rest) / walking speed. The Pearson Product-Moment technique was used in all correlation analysis. Differences were considered significant at $p<0.05$.

Results

The relationship between walking speed and oxygen uptake

In all cases oxygen uptake increased with increasing walking speed (Fig.2).

The relationship between walking speed and PCI

With the exception of case 5 PCI increased with increasing walking speed in each case. In case 5 PCI fell slightly at FWS and 1.2 times that speed, but there was a rising trend at 1.4 times and 1.6 times (Fig.3).

The relationship between PCI and oxygen uptake

In each case the index of correlation between PCI and oxygen uptake in response to walking

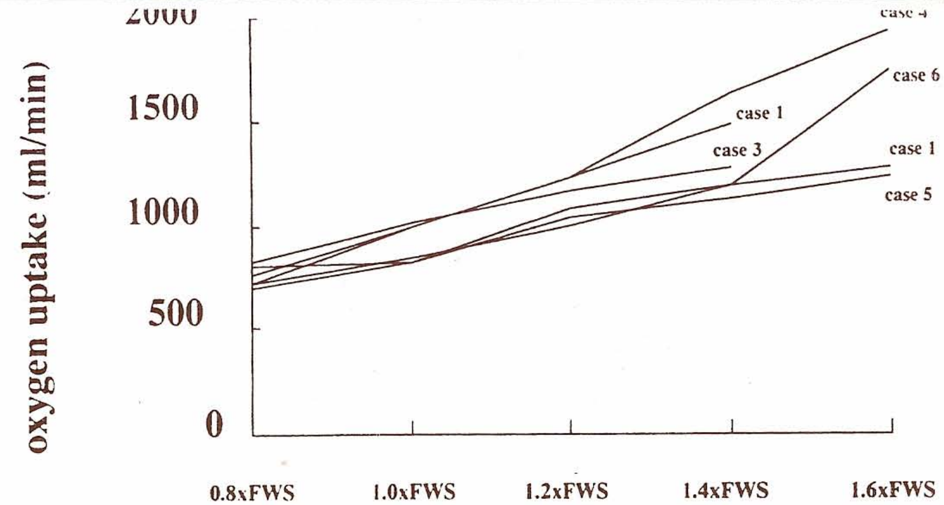

Fig. 2. The relationship between walking speed and oxygen uptake for each case.

speed was calculated. A significant correlation was observed between PCI and oxygen uptake in each case. In case 1 the correlation coefficient for the relationship between PCI and oxygen uptake was 0.926, indicating a significant correlation between the two ($p<0.05$). In case 2 the correlation coefficient was 0.972 ($p<0.001$). In case 3 the correlation coefficient was 0.751 ($p<0.001$). In case 4 the correlation coefficient was 0.997 ($p<0.01$). In case 5 the correlation coefficient was 0.907 ($p<0.05$). In case 6 the correlation coefficient was 0.903 ($p<0.05$). Figure 4 shows an example of the correlation for case 4.

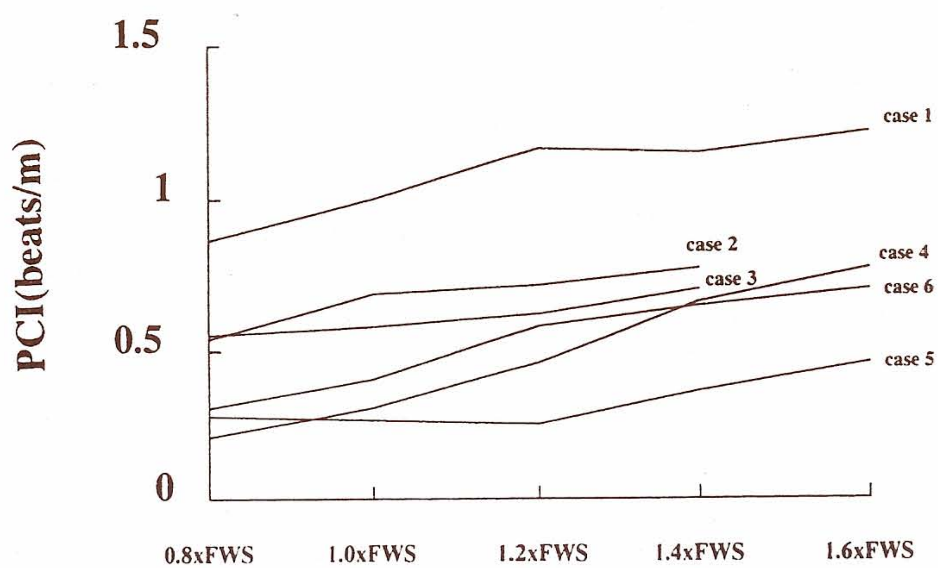

Fig. 3. The relationship between walking speed and PCI for each case.