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Minnesota Leisure Time Physical Activity Questionnaire as an additional Tool in Clinical Assessment of Patients undergoing Percutaneous Coronary Interventions

by
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The aim was to analyze the usability of Minnesota Leisure Time Physical Activity Questionnaire (MLTPAQ) in assessment of physical activity in patients before and 6 months after percutaneous coronary intervention (PCI). The study group consisted of 211 patients aged between 34-79 years (x = 59,5±7,89 yeras), with history of ischemic heart disease (IHD) with or without previous incidence of myocardial infarction (MI). The MLTPAQ was administered to all patients at the time of PCI and then 6 months later, as was the treadmill stress test (TST) and echocardiography (ECHO). Total energy expenditure calculated with the MLTPAQ remained at the same level and was of low intensity (<4 MET, <2000kcal/week) 6 months after the PCI. There was an increased physical capacity noted 6 months after initial PCI: increased metabolic cost (MET); maximal oxygen uptake (VO_{2max}); maximal heart rate (HR_{max}) obtained during the TST and decreased resting heart rate (HR_{rest}). ECHO examination showed improved LVEF%. Despite increased physical capacity and improved heart hemodynamics, resulting most likely from PCI procedure, the patients showed a similar level of leisure time physical activity 6 months after the PCI.

Key words: ischemic heart disease, percutaneous coronary intervention, physical activity questionnaire, treadmill stress test.

Introduction

In the recent years there have been many papers published on the research methods aimed at measuring physical activity. Some were based on monitoring selected physiological parameters, such as heart rate and whole body movements with the use of accelerometers or pedometers (Zakeri et al., 2008; Bravata et al., 2007, Bohannon 2007; Rothney et al., 2008; Epstein et al., 2005). Others were aimed at assessment of energy expenditure derived from food, using direct and indirect calorimetry, kinematic analysis, as well as doubly labeled water (Bonnefoy et al., 2001; Paffenbarger et al., 1993).

In epidemiological studies, the application of the above captioned methods is limited due to high costs, lack of appropriate equipment, advanced age of subjects, their health status and potential contraindications Considering the above, it seems that a questionnaire/interview appears to be the simplest and least expensive tool in assessing physical activity, feasible for large population surveys (Paffenbarger, 1997; Montoye et al., 1996; Aaron et al., 1995; Eaton et al., 1994; Berenstein et al., 1998). In some questionnaires, only occupational activity is of interest, in others, only leisure time exercise, but many

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seek information about both activities, on and off the job. The questionnaires assess the physical activity over a wide age range for various periods of time - the previous 24 hr, the previous week, month or even a year (Paffenbarger, 1997). The data obtained in this way allows for calculation of energy expenditures of an individual with the use of suitable tables. This enables us to state whether the form, frequency and intensity of physical activity reach the values required for prevention and treatment of many so-called civilization diseases, including ischemic heart diseases (IHD). Such measurements are of great importance, since the sedentary lifestyle is one of the primary risk factors responsible for the occurrence of IHD, and at the same time physical activity constitutes a major factor in treatment and secondary prevention of IHD (Chakravarthy et al., 2002; Haskell et al., 2007). However, the number of studies done on the application of questionnaires for clinical purposes in patients with IHD is limited. The objective of the present study was to assess the level of physical activity and its changes after the percutaneous coronary intervention (PCI) in patients with IHD with the use of MLTPAQ (Paffenbarger, 1997) administered twice. For the first administered questionnaire, the questions concerned the 6-month period before the hospitalization due to IHD, and for the second questionnaire, the following 6-month period was assessed. Physical capacity and heart hemodynamics were assessed twice, accordingly.

Material and methods

The study was carried out in the Department of Cardiology, Silesian School of Medicine in Katowice, Poland . The study group consisted of 211 patients, aged between 34-79 years (mean age of 59 ± 9), among which there were patients with acute MI, with history of past MI and with IHD without MI. Patients with post-MI complications, such as cardiogenic shock, circulatory arrest, pericarditis, resting arrhythmias and heart conductivity disorders, were excluded from the study. All patients were informed about the type and aim of the research, and they gave written informed consent before participating in the study. Subjects were told that they may withdraw from the study at any time. The study was approved by the Senate Ethics Committee of the Academy of Physical Education in Katowice, Poland. All subjects underwent coronary angiography procedure with optional percutaneous coronary intervention (PCI). Out of 211 patients, 51 subjects (24,2%) did not receive stent implantation, 145 subjects (68.72%) received one stent, while 15 subjects (7,10%) required two stents. All patients underwent phase I, inpatient cardiac rehabilitation, which lasted from 5 to 7 days. After hospitalization, all patients were referred to phase II, 24-day cardiac rehabilitation in a health resort (sanatorium). All subjects completed the MLTPAQ twice. First, at the time of hospitalization due to PCI procedure, and then for the second time after the lapse of 6 months. The MLTPAQ results enabled the calculation of the level of recreational physical activity and household activities during leisure time. The results were expressed in a weekly value [kcal/week] after dividing the calculated 6-month energy expenditure by 26 weeks. The following ranges of activity intensity were used: low [< 4 MET], medium [4 - < 6 MET] and high [≥ 6 MET], where 1 MET equals the resting metabolic rate, which is approximately 3.5 ml oxygen kg^{-1} body weight per min^{-1}. The value of the total averaged weekly energy expenditure was calculated separately for recreational activity (RA) and household activity (HA) (shopping, cleaning, gardening, house remodeling and repairing). Additional categorization of weekly energy expenditure, divided among 4 ranges was also made: ≤ 999, 1000-1999, 2000-2999, ≥ 3000 [kcal/week]. The MET for a given activity value was calculated according the Compendium of Physical Activities Tracking Guide (Ainsworth et al., 2000). In order to increase reliability of the questionnaire calculations (avoiding possible misunderstanding of some questions, especially those concerning the time of activity), the authors of this study read the questions of the MLTPAQ, and filled in the questionnaires for patients during individual appointments.

The level of work capacity was assessed with the use of submaximal treadmill stress test (7 levels according to Bruce's protocol) performed 1-3 months before the initial PCI procedure and 6 months after. The following variables of stress test were subjected to statistical analysis: test duration [min], metabolic cost [MET], resting heart rate, and the highest recorded heart rate [beats/min], maximal oxygen consumption VO_2max [ml] and the reason for stress test termination: submaximal value of HR calculated with formula: (220 – age) x 0,85, fatigue, stenocardia, changes of S-T segment in electrocardiogram (ECG), occurrence of arrhythmias, heart conductivity disorders and excessive increase in arterial blood pres-

sure. The value of VO_2max was calculated according to the following formula (Foster et al., 1984):

$$VO_2max = 13,3 - 0,03\ (t) + 0,297\ (t^2) - 0,0077\ (t.^2) + 4,2\ (CHS)$$

where, t - time [minutes], CHS - cardiac health status, 1- patients with angina pectoris, after MI, after PCI, 0 – patients without clinical symptoms of angina pectoris, without history of MI or PCI.

The assessment of heart structure was done with 2-dimensional echocardiography (HP Sonos 1100) by a cardiologist, after completion of echocardiography training. The following parameters were analyzed: left ventricular end-diastolic diameter (LVEDD), left ventricular end-systolic diameter (LVESD), left ventricular ejection fraction (LVEF%) and left ventricular mass (LVM) calculated with the following formula (Juo et al., 2005; Devereux et al., 1986):

$$LVM = 0,8 \times (1,04 \times [(LVEDD + IVS + LVPW)^3 - LVEDD^3]) + 0,6$$

where: LVEDD – left ventricular end-diastolic diameter [mm], IVS – interventricular septum [mm], LVPW – left ventricular posterior wall [mm].

Left ventricular mass index LVMI was calculated with the Devereux formula (Devereux et al., 1986):

$$LVMI = LVM / BSA$$

where: LVM – left ventricular mass [g], BSA – body surface area [m^2] according to Dubois & Dubois formula (Dubois et al., 1916):

$BSA = \text{body mass (kg)}^{0,425} \times \text{body height (cm)}^{0,725} \times 71,84$

One of the criterions used for patients' assessment was the combined endpoint, with a variety of outcomes such as: death, MI, unstable IHD, the need for additional PCI or PCI + stent implantation or coronary artery bypass grafting (CABG). Combined endpoints were found in 37 patients (17,53%). During the 6-month period there were two cases of death (0,94%), 4 subjects (1,89%) underwent CABG procedure, and the remaining 31 patients (14,69%) needed another PCI with stent implantation due to recurrence of unstable IHD. In order to verify the correlation between the amount of weekly energy expenditure related to physical activity and occurrence of one of the combined endpoints, we compared results obtained from the MLTPAQ between patients without and with at least one of the combined endpoints.

All statistical analyses were performed using Statistica (v. 7.1) software, Statsoft USA and MedCalc software (v.8.0.0.1) by F.Schoonjans, and included the calculation of means and standard deviations (SD) of variables. The distribution of means was evaluated with Wilk-Shapiro test for normality. A criterion of $p<0.05$ defined statistical significance. Student's t-test for independent variables with normal distribution was used. This test was preceded by the Fisher's test for verification of the homogeneity of variance. In case the variance was not equal, Sattherwaite's test was used. Student's t-test for dependent variables was also used, as well as one-way analysis of variance, preceded by Bartlett's test for verification of variance homogeneity. For variables with non-normal distribution, U Mann-Whitney test, Kruskall-Wallis ANOVA test and Sperman's rang correlation test were used.

Results

Out of 211 patients who initially underwent PCI procedure, 207 were administered the second questionnaire (2 patients died due to coronary insufficiency in the second and fifth month after PCI, 2 patients resigned from the study due to general discomfort). Initially, the study group was divided into two subgroups: patients under age of 50, and over the age of 50. Since the statistical analysis showed no difference between these two groups in the level of physical activity, at the time of the initial PCI and 6 months later, the results are shown as one group for all subjects. Compared to the stress test performed at the time of the initial PCI procedure, the improvement in patients' physical capacity was noted during the second treadmill stress test performed after 6 months: increased metabolic cost (MET); maximal

Table 1

Minute Results of treadmill stress test at the time of PCI and 6 months after

Parametr*	at the time of PCI, N = 211	6 months after PCI, N = 207	P
Stress test time [min]	5,82±2,67	7,48±2,47	<0,001
MET	7,57±2,65	9,18±2,60	<0,001
VO_2max [ml]	29,23±9,97	34,79±10,50	<0,001
Resting HR [beats/min]	77±9,31	73±9,87	<0,001
HR_{max} at the test [beats/min]	123±17,32	132±14,57	<0,001

**Abbreviations: PCI - percutaneous coronary intervention; MET - metabolic cost; VO_2max - maximal oxygen consumption; HR_{rest}.- resting heart rate; HR_{max} - maximal heart rate*

Table 2

Indications for treadmill stress test termination

Indications for stress test termination	at the time of PCI*		6 months after PCI	
	N	%	N	%
Reaching submaximal HR*	25	11,85	123	68,33
Other†	186	88,15	57	31,67
Total	211	100	180	100
		P <0,001		

*Abbreviations: PCI - percutaneous coronary intervention; HR - heart rate;† stenocardia, S-T segment changes in ECG, occurrence of arrhythmias and heart conductivity disorders, excessive increase in arterial blood pressure

oxygen uptake (VO_{2max}); maximal heart rate (HR_{max}) obtained during the test and decreased resting heart rate (HR_{rest}) (Table 1). The number of patients who terminated the stress test due to pathological reasons was reduced in the second stress test 6 months later (Table 2).

After the 6-month period, there was a favorable tendency noted in the changes of selected parameters of heart hemodynamics, though only in EF% was statistical significance observed (Table 3).

The total energy expenditure from leisure time activities, calculated with the MLTPAQ, was slightly higher 6 months after the angioplasty procedure (2829,52 vs 2799,92kcal/week). As far as physical activity of low intensity was concerned, there was an increase noted (1759,30 vs 1811,06 kcal/week). The values of activity of medium and high intensity dropped from 1300,99 to 1190,46 and from 714,63 to 491,73 kcal/week, respectively. Nevertheless, none of the above changes were statistically significant. The value of recreational activity was higher 6 months after the angioplasty for low intensity (<4 MET) and in the majority of patients it did not exceed 3000 kcal/week (>6 MET). In the range of medium intensity (4-6 MET), energy expenditure stayed under 2000 kcal/week in majority of patients. In the range of high intensity (> 6MET), energy expenditure only occasionally exceeded 3000 kcal/week in those few patients who presented within that level of high intensity. In case of household activity, there was an increase noted in medium range of intensity (4-6 MET), and rarely exceeded 3000 kcal/week (>6 MET) in the majority of patients. For household activities of high intensity (>6 MET), there was a significant drop in the all four ranges of energy expenditure (Table 4).

Table 3

Echocardiography results

Parametr*	at the time of PCI, N = 211	6 months after PCI, N = 207	P
LVEDD [mm]	51,10 ± 6,44	51,35 ± 6,08	<0,17
LVESD [mm]	34,93 ± 6,86	34,33 ± 6,80	<0,06
LVEF%	51,64 ± 9,12	52,45 ± 8,34	**<0,02**
LVM [g]	210,64 ± 58,69	207,86 ± 54,01	<0,52
LVMI [g/m²]	110,82 ± 29,50	109,86 ± 27,00	<0,77

*Abbreviations: PCI - percutaneous coronary intervention; LVEDD- left ventricular end-diastolic diameter; LVESD- left ventricular end-systolic diameter; LVEF% – left ventricular ejection fraction; LVM – left ventricular mass; LVMI- left ventricular mass index

There was a significant increase in work tolerance noted during the stress test 6 months after the angioplasty. There were considerable changes in values of all observed parameters. Patients whose physical activity in leisure time was in the range of 2000-2999 and over 3000 kcal/week, obtained the most significant improvement during the stress test (Table 5).

The echocardiography examination performed 6 months after the angioplasty showed improvement in heart structure dimensions. Statistically significant changes (within the normal range) were observed in LVESD and LVEF% values. In the group of patients whose weekly energy expenditure was below 2000 kcal/week, there was a slight increase in dimensions in the majority of parameters, except for LVEF%, where there was a small decrease (within the normal range) observed in the group of patients with weekly energy expenditure under 999 kcal/week (Table 6).

There were weak correlations observed between total energy expenditure calculated with the MLTPAQ and stress test parameters (Table 7).

Weekly energy expenditure related to recreational and household activity was lower in patients with the combined endpoint, than in the group without it, by 478 kcal/week; yet the statistical analysis did not show any significant difference between these two groups (Table 8).

Table 4

Types and ranges of physical activity energy expenditure calculated with the MLTPAQ

Parameter*		before PCI	6 months after PCI.	P
Low intensity < 4 MET				
RA	Mean	**1639,94**	**1727,99**	<0,26
	SD	**1262,93**	**1119,06**	
	N	**186**	**190**	
HA	Mean	**1730,29**	**1480,53**	<0,46
	SD	**1771,22**	**1581,89**	
	N	**14**	**18**	
Total	Mean	**1759,30**	**1811,06**	<0,36
	SD	**1421,13**	**1291,56**	
	N	**187**	**196**	
Medium intensity 4 - < 6 MET				
RA	Mean	**596,15**	**617,27**	<0,18
	SD	**578,86**	**710,96**	
	N	**122**	**115**	
HA	Mean	**1172,72**	**1084,13**	<0,78
	SD	**1429,76**	**1049,48**	
	N	**112**	**119**	
Total	Mean	**1300,99**	**1190,46**	<0,94
	SD	**1336,26**	**1098,55**	
	N	**166**	**168**	
High intensity ≥6 MET				
RA	Mean	**575,94**	**673,90**	<0,7
	SD	**659,73**	**1115,09**	
	N	**28**	**24**	
HA	Mean	**770,74**	**280,34**	<0,53
	SD	**1220,53**	**252,87**	
	N	**31**	**35**	
Total	Mean	**714,63**	**491,73**	<0,6
	SD	**1092,74**	**806,73**	
	N	**56**	**52**	
Total energy expenditure	Mean	**2799,92**	**2829,52**	<0,41
	SD	**1954,14**	**1702,64**	
	N	**209**	**205**	

Abbreviations: PCI - percutaneous coronary intervention **RA- energy expenditure of recreational activity, **HA** – energy expenditure of household activity*
***Total** – energy expenditure of either RA, HA or both forms of activity; SD – standard deviation*

Table 5

Selected parameters of stress test in relation to the intensity ranges of activity calculated with the MLTPAQ

Parameter*		before PCI	6 months after PCI	P
Test duration [min]	Mean	**5,81**	**7,47**	**<0,001**
	SD	**2,69**	**2,49**	
	N	**209**	**178**	
Metabolic cost [MET`s]	Mean	**7,55**	**9,19**	**<0,001**
	SD	**2,66**	**2,62**	
	N	**209**	**178**	
VO_2max [ml/kg/min]	Mean	**29,22**	**34,77**	**<0,001**
	SD	**10,02**	**10,57**	
	N	**209**	**178**	
HR resting [beats/min]	Mean	**77,23**	**73,40**	**<0,001**
	SD	**9,20**	**9,89**	
	N	**209**	**178**	
HR max [beats/min]	Mean	**123,49**	**132,11**	**<0,001**
	SD	**17,36**	**14,63**	
	N	**209**	**178**	
HR submax not reached	N/Σ	**132/209**	**63/178**	**<0,001**
	%	**63,16%**	**35,39%**	
Positive results of stress test	N/ Σ	**184/209**	**57/178**	**<0,001**
	%	**88,04%**	**32,02%**	

**Abbreviations: PCI - percutaneous coronary intervention; MET - metabolic cost; VO_2max - maximal oxygen consumption; $HR_{rest.}$- resting heart rate; HR_{max} - maximal heart rate: HR sumbax - HR calculated with formula: (220 – age) x 0,85; SD – standard deviation*

Table 6

Selected echocardiography variables, in relation to the intensity ranges of activity calculated with the MLTPAQ

Parameter		before PCI	6 months after PCI	*P*<
LVEDD [mm]	Mean	51,15	51,38	<0,33
	SD	6,45	6,07	
	N	209	202	
LVESD [mm]	Mean	34,97	34,34	<0,01
	SD	6,89	6,82	
	N	209	202	
LVEF% [%]	Mean	51,53	52,42	<0,03
	SD	9,10	8,35	
	N	209	202	
LVM [g]	Mean	210,65	207,89	<0,63
	SD	58,84	54,15	
	N	209	202	
LVMI [g/m²]	Mean	110,83	109,87	<0,8
	SD	29,57	27,07	
	N	209	202	

**Abbreviations: PCI - percutaneous coronary intervention; LVEDD- left ventricular end-diastolic diameter; LVESD- left ventricular end-systolic diameter; LVEF% – left ventricular ejection fraction; LVM – left ventricular mass; LVMI- left ventricular mass index; SD – standard deviation*

Discussion

We found that before the initial PCI procedure, the mean value of recreational and household weekly energy expenditure in the majority of subjects was below 1000kcal, which is below the strongly recommended prophylaxis measure for IHD (Ainsworth et al., 2000; Nelson et al., 2007; Steffen et al., 2006) of 2000 kcal/week, and thereby constituted mainly light activity (below 4 MET, morning warm-up exercises, walking, fishing) and medium activity (4 – 6 MET, biking, also stationary, general conditioning exercises). Such low level of physical activity may result from limitation of exercise tolerance due to atherosclerotic processes in

Table 7

Correlation indices between total energy expenditure calculated with MLTPAQ,stress test parameters and ECHO results

	Exercise stress test	r	P	Echocardio graphy	R	P
MLTPAQ*Δ†	Time Δ†	0,221	**<0,003**	**LVEDD Δ**	-0,062	<0,379
MLTPAQ Δ	MET Δ	0,146	<0,053	**LVESD Δ**	0,06	<0,398
MLTPAQ Δ	VO_2max Δ	0,248	**<0,001**	**EF% Δ**	0,022	<0,759
MLTPAQ Δ	Rest.HR Δ	0,146	<0,052	**LVM Δ**	-0,058	<0,41
MLTPAQ Δ	HR max Δ	0,127	<0,092	**LVMI Δ**	-0,07	<0,325

* *Minnesota Leisure Time Physical Activity Questionnaire*

† *Δ: the result of subtraction of the first and second examination and MLTPAQ values*

coronary vessels or history of MI, but most likely from a sedentary lifestyle (Steffen et al., 2006). Majority of patients did not engage in any form of physical activity of sport or recreational type, and even if they had, such activity was short-lasting and rare, both during the 6-month period before and after the PCI. There were, however, 8 patients (3,8% of all patients) who systematically participated in various forms of recreation (skiing, jogging, swimming). Their weekly energy expenditure resulting from such activities very often exceeded 2000 kcal/week and periodically even greater than 3000 kcal/week.. This group of few patients included individuals who formerly participated in sports or who were really enjoying such activities. After the angioplasty procedure, the increase in level of physical activity, as well as energy expenditure, was anticipated. We assumed that one of the factors which had favorably affected patients' attitude to physical activity was the cardiac rehabilitation program, both in hospital and in sanatorium. Part of the program were the counseling meetings, during which patients were encouraged to increase their physical activity Indeed, higher values of weekly energy expenditure were noted (though with no statistical significance), but detailed analysis revealed that those differences resulted rather from frequency and time commitment of the activity, but neither from type nor from intensity. Recreational activities of low intensity and household activities of medium intensity were prevailing in the 6-month period after the initial PCI. Physical activity level of this group of patients was also assessed with the use of Paffenbarger Physical Activity Questionnaire in our other study (Nowak et al.2010), which revealed similar results as documented in the present paper. Therefore it may be stated that majority of patients who underwent the PCI procedure did not take the advantage of their increased physical potential and did not reach the required preventive level of 2000kcal per week of leisure time physical activity as recommended by WHO guidelines. The observed changes (though not significant) noted in physical activity level calculated with the second MLTPAQ were also reflected by results of the exercise stress test. As it was revealed by correlation analysis, the higher the increase in energy expenditure in relation to the initial examination, the more improvement in selected stress test parameters (test time duration and VO_2 max) was noted.. It is worth noting, that there were fewer positive treadmill stress test results in group of patients who increased their level of physical activity above the level of 2000kcal per week after the PCI. Similar findings were reported by Richardson et al. (1994) who performed comprehensive evaluations of MLPAQ in their study.

The angioplasty procedure, improves contractility of left ventricle and thus, allows patient to exercise longer and with increased intensity. The procedure resulted in improvement of left ventricle function of studied subjects (increase in EF%, reduced

Table 8

Comparison of the MLTPAQ results between the group of 174 patients without the combined endpoint and the group of 37 patients with occurrence of combined endpoint during the 6-month period after the PCI

	Patients without combined endpoint N=174	Patients with combined endpoint N=37
MLTPAQ* [kcal/week]	2878,9±1987,38	2400,9±1762,20
	p<0,18	

* *Minnesota Leisure Time Physical Activity Questionnaire*

LVESD), which was also reported by other authors (Agirbasli and Guler, 2005; Hu et al 2004; Nechvatal et al., 2003; Zellweger et al., 2004). We also evaluated correlation between the delta of energy expenditure assessed in the questionnaire versus the delta of selected parameters of treadmill stress test and echocardiography examination. As far as stress test results were concerned we found weak correlation with the delta of test time and VO_2 max. There were however no association with the delta values of echocardiography procedure. This situation may result from patients' fear of ischemic symptoms reproduction associated with considerable chest pain and perhaps from their unwillingness to physical effort in general.

To determine if the MLTPAQ may be used as an additional tool in clinical studies, we compared the calculated value of weekly energy expenditure of 37 patients with combined endpoint, with results of the other 174 patients. Comparison of total weekly energy expenditure and comparison of different intensity activities (low, moderate, high) and its type (recreational and household) appeared to be advantageous for patients without the combined endpoint, however there were no statistical significances noted between compared variables. Perhaps, if the observation lasted longer and if there were more patients with combined end point, it would be possible to prove that the MLTPAQ could be used in prediction of combined endpoints in patients with IHD. It should be also taken into consideration that a questionnaire is always a subjective method of measuring physical activity; therefore subjects do not necessarily recall their activity accurately and sometimes tend to overestimate its time and intensity, which might have happened to patients with combined end point in the presented study (Montoye et al., 1996).

Our findings suggest that MLTPAQ may be used as an additional tool in clinical assessment of patients undergoing PCI. The results obtained in this study indicate that the level of leisure time physical activity in studied subjects was below the value recommended for secondary prevention of IHD, in spite of patients' increased physical potential. We assume that improvement in patients' clinical status 6 months after the PCI resulted from high effectiveness of the surgical procedure and participation in two phases of cardiac rehabilitation.

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