J Rehabil Med 2005; 37: 108–114

Taylor & Francis
Taylor & Francis Group

CORRELATION BETWEEN A NOVEL UPPER LIMB ACTIVITY MONITOR AND FOUR OTHER INSTRUMENTS TO DETERMINE FUNCTIONING IN UPPER LIMB COMPLEX REGIONAL PAIN SYNDROME TYPE I

Fabiënne C. Schasfoort, Johannes B. J. Bussmann and Henk J. Stam

From the Department of Rehabilitation Medicine, Erasmus MC, Rotterdam, The Netherlands

Objective: **To determine the place of a novel Upper Limb Activity Monitor in the field of instruments measuring functioning and health in upper limb complex regional pain syndrome type I, by exploring the correlation between the Upper Limb Activity Monitor and 4 questionnaires.**

Method: **Subjects ($n = 30$) were measured at home and correlations were calculated between the Upper Limb Activity Monitor and 4 questionnaires; Sickness Impact Profile, RAND-36 Health Survey, Disabilities of Arm Shoulder Hand Questionnaire and Radboud Skills Questionnaire.**

Results: **Of the inter-questionnaire correlations 83% were significant, whereas 46% of the correlations between the Upper Limb Activity Monitor and the questionnaires were significant. The number and strength of the correlations between the Upper Limb Activity Monitor and questionnaires was dependent on the degree to which similar aspects of functioning were measured.**

Conclusion: **The Upper Limb Activity Monitor has some correlation with other instruments related to functioning and health, but generally it does not measure the same areas.**

Key words: ambulatory accelerometry, questionnaires, activity limitations, functioning.

J Rehabil Med 2005; 37: 108–114

Correspondence address: F. C. Schasfoort, Department of Rehabilitation Medicine, Room Ee 1626 B, Erasmus MC, University Medical Center Rotterdam, PO Box 1738, 3000 DR Rotterdam, The Netherlands.
E-mail: f.schasfoort@erasmusmc.nl

Submitted August 22, 2003; accepted June 28, 2004

INTRODUCTION

For many medical disciplines, and in particular for rehabilitation medicine, objective instruments and quantifiable outcome measures that focus on the functional consequences of diseases are essential (1). In the International Classification of Functioning (ICF), the concepts “activity limitations” and “participation restrictions” are classified as 2 components of health at the level of the person and society, respectively (2). These concepts can be measured in different ways (3, 4) but, until recently, objective, reliable and valid instruments were lacking (5).

To measure objectively activity limitations of subjects with upper limb disorders, an Upper Limb Activity Monitor (ULAM) has been developed (6), based on a previously developed Activity Monitor (AM) that allows valid determination of limitations related to mobility (7). The ULAM is based on long-term ambulatory monitoring and consists of body-fixed acceleration sensors connected to a recorder. The ULAM has proven its ability to detect limitations of upper limb activity of subjects with upper limb complex regional pain syndrome type I (CRPSI) when compared with healthy subjects (8). The main characteristics of the ULAM are that it measures actual daily behaviour, that behaviour is measured in an objective and non-retrospective way, that behaviour is described in terms of generic (body postures and motions) and body-part specific (upper limb activity) outcome measures, and that it mainly measures at the ICF activity level, although some aspects of participation are also measured indirectly.

CRPSI is a disorder that may comprise sensory, trophic, autonomic and motor impairments. When it occurs, it usually follows surgery or trauma and is generally expressed in the limbs (9). The pathophysiology of CRPSI remains controversial (10, 11) and it may lead to activity limitations and participation restrictions (12–15). Up to now, only scales and questionnaires have been applied to determine activity limitations and participation restrictions in CRPSI (16). These instruments are in general characterized by measuring functioning as perceived and recalled by subjects, standardized response options, retrospective data collection, and functioning is described beyond terms of body postures and motions and upper limb activity.

The measurement area of the ULAM compared with the areas of other instruments for functioning and health is not yet fully clarified. Exploration of the relationships between questionnaires and ULAM will contribute to the assessment of and discussions about the characteristics and added value of the ULAM. For example, it can be hypothesized that the mutual relationships between questionnaires are stronger than the relationships between ULAM and questionnaires. A more detailed analysis of the relationships, e.g. between the ULAM and total scores of questionnaires, will provide further insight. The aim of this study therefore was to determine the area of the ULAM in measuring functioning and health in upper limb complex regional pain syndrome type I.

 ISSN 1650–1977
DOI 10.1080/16501970410022093

METHODS

Design and subjects

Thirty subjects (29 women, 1 man) with CRPSI in 1 upper limb volunteered for this cross-sectional explorative study. Their average age was 55.1 (SD ±14.9, range 20–81) years. In 15 subjects the dominant side was involved and in the other 15 the non-dominant side was involved. Mean duration of CRPSI was 33 months. Inclusion criteria were: (i) presence of Veldman's criteria (17) at diagnosis, which do not substantially differ from the official IASP criteria (9, 11) and (ii) presence of CRPSI-related complaints at enrolment. Subjects were excluded if they had co-morbidities that might influence functioning.

Instruments and outcome measures

Two generic questionnaires, 2 body-part specific questionnaires and the ULAM were used. The ULAM consists of acceleration sensors (Analog devices, ADXL202, uni-axial piezo-resistive, size $1 \times 1 \times 0.5$ cm) on forearms, thighs and trunk connected to a waist-worn recorder (TEMEC Instruments BV, Kerkrade, The Netherlands) (Fig. 1). The raw signals are a combination of gravitational acceleration and accelerations due to activity. Data were stored on a PCMCIA card and downloaded onto a PC for automatic post-measurement kinematic analysis using signal processing and inferencing language (SPIL) routines. Briefly, the accelerometer signals from the thighs and the trunk allow mobility-related activities (such as lying, sitting, standing, walking, cycling and general movement) to be automatically detected. Two of the generic ULAM outcome measures presently used were the percentage of the measurement period that a person was "dynamic" (i.e. walked, walked stairs, cycled, moved without cyclic movements) (ULAM-%dyn), and body motility (the intensity of body movement measured with accelerometry, expressed in scaled ms^{-2}) (ULAM-body), a general measure for the amount and intensity of everyday physical activity. The addition of accelerometers on the forearms allowed us to calculate 4 body-part specific ULAM measures: the mean intensity of upper limb activity of the involved side during the time subjects were sitting and standing (ULAM-isit and ULAM-istand, expressed in scaled ms^{-2}) and the percentage of the time that the upper limb was active (i.e. exceeding certain threshold values) during the time subjects were sitting and standing (ULAM-%sit, ULAM-%stand). The lower the scores, the worse the functioning. A more extensive description is given in earlier studies (6–8).

Fig. 1. A woman wearing the Upper Limb Activity Monitor (ULAM), which was fitted in her home environment.

The body-part specific Radboud Skills Questionnaire (RASQ) (13) reliably scores the effort certain activities cost compared with pre-CRPSI; it has only been used in upper limb CRPSI (18). The RASQ personal care outcome measure (RASQ-pc) describes personal hygiene, getting dressed and eating/drinking, the domestic activities part (RASQ-da) describes housekeeping, meal preparation and taking care of clothes, and the recreational activities part (RASQ-ra) describes sports and hobbies. The social activities outcome measure (RASQ-sa) describes going out, holiday/vacation and playing with children or pets, the other items part (RASQ-oi) scores communication (writing and typing) and transportation (bicycle, car, public), and work-related part (RASQ-w) refers to occupation (excluding household activities). For each item subjects scored from 1 (normal) to 5 (not done anymore), with a lower score representing better functioning.

The body-part specific Disabilities of Arm Shoulder and Hand Questionnaire (DASH) has been developed to determine limitations of the entire upper limb (19); the Dutch version (20) has not been used in CRPSI. The DASH function symptoms score (DASH-fss) included 21 items related to everyday activities (prepare a meal, lock a door, similar to RASQ items), 6 items related to body structures and functions (pain, tingling), and 3 items related to social participation (undertaking activities with friends and family). These 30 items were transformed into 1 score ranging from 0 to 100, with a lower score indicating better functioning.

The generic RAND36 Health Survey (21) is a valid Dutch version of the Short Form 36 (22) but with different scoring rules; the RAND36 has been used in CRPSI research (14, 15). The physical functioning score (RAND36-pf) contains items such as walking (stairs), washing up, getting dressed, lifting a heavy bag, and the social functioning score (RAND36-sf) describes the influence of physical and/or emotional problems on undertaking activities with friends and family. The physical role limitations score (RAND36-prl) refers to interference of physical problems with time spent with work or other engagements, satisfaction with accomplishments and the effort, while the emotional role limitations score (RAND36-erl) refers to interference of emotional problems. The other RAND36 scores were related to mental health (RAND36-mh), vitality (RAND36-vit), bodily pain (RAND36-bp) and general health perception (RAND36-ghp). A higher score represented better functioning.

The generic questionnaire Sickness Impact Profile (SIP) measures the impact of a disease on everyday functioning (23). The SIP68 is a reliable and valid short version (24) of the original SIP; both have been applied in CRPSI (18, 25). The somatic autonomy score (SIP68-sa) describes autonomy in basic somatic functioning (getting dressed, standing, walking, eating and help needed), the mobility control score (SIP68-mc) describes the level of body control (walking and arm-hand control), and the psychological autonomy score (SIP68-pa) describes the ability to mentally function (including communication) without help. The social behaviour score (SIP68-sb) describes functioning in relation to others (sexual activity, visiting friends and group activities), the emotional stability score) (SIP68-es) assessed the effect of health status on emotions (irritability and acting disagreeably), and the mobility range score (SIP68-mr) describes the influence of health status on everyday tasks like shopping, housecleaning and taking care of personal affairs. Only those items that a subject was sure to describe the current health situation were scored, with a lower score indicating better functioning.

The study was approved by the local Ethical Committee and all subjects gave informed consent. All measurements took place in the subjects' home environment. On the first day, the ULAM was fitted and subsequently worn for 24 hours. Subjects were instructed to continue their usual everyday life, but not to swim, bathe or shower. The next day, the ULAM was removed and the exact measurement technique was explained. Then, the 4 questionnaires were administered.

Data analysis and statistics

For the questionnaires, the total score, the individual outcome measures, the number of items these outcome measures consist of, as well as their

Table I. *Overview of characteristics of the Upper Limb Activity Monitor (ULAM) and the 4 questionnaires RAdboud Skills Questionnaire (RASQ), Disabilities of Arm Shoulder Hand questionnaire (DASH), RAND-36 Health Survey (RAND-36) and Sickness Impact Profile (SIP68)*

Instrument & outcome measures (number of items)	Type of instrument	Performance and/or capacity*	HRQoL domain	Abbreviation in text	ICF level
RASQ	BPS, CS(p)	Perf, Cap(p)	POF		A, P(p)
RASQ-total (45)				RASQ-tot	
Personal care (13)				RASQ-pc	A
Domestic activities (19)				RASQ-da	A
Recreational activities (2)				RASQ-ra	A
Social activities (3)				RASQ-sa	A
Other items (7)				RASQ-oi	A
Work (1)				RASQ-w	A
DASH	BPS, G(p), CS(p)	Cap	POF, PS(p), SI(p), SS(p)		A, FS(p), P(p)
Function Symptoms Score (30)				DASH-fss	A
RAND-36/SF-36	G, BPS(p)	Cap, Perf(p)	POF, PS, SI, SS		A, P, FS(p)
RAND-36 total score (35)				RAND36-tot	
Physical functioning (10)				RAND36-pf	A
Social functioning (2)				RAND36-sf	P
Physical role limitations (4)				RAND36-prl	P
Emotional role limitations (3)				RAND36-erl	P
Mental health (5)				RAND36-mh	P
Vitality (4)				RAND36-vit	P
Bodily Pain (2)				RAND36-bp	FS
General health perception (5)				RAND36-ghp	nd
SIP68	G, BPS(p)	Perf, Cap(p)	POF, PS, SI		A, P
SIP68-total (68)				SIP68-tot	
Somatic autonomy (17)				SIP68-sa	A
Mobility control (12)				SIP68-mc	A
Psychological autonomy and communication (11)				SIP68-pa	nd
Social behaviour (12)				SIP68-sb	A, P
Emotional stability (6)				SIP68-es	P
Mobility range (10)				SIP68-mr	A
ULAM	G, BPS	Perf	POF† SI(p)		A, P(p)
Percentage spent in dynamic mobility-related activities				ULAM-%dyn	A
Mean intensity of body activity				ULAM-body	A
Mean activity intensity involved limb during sitting				ULAM-isit	A
Mean activity intensity involved limb during standing				ULAM-istand	A
Percentage of activity involved limb during sitting				ULAM-%sit	A
Percentage of activity involved limb during standing				ULAM-%stand	A

G = generic, BPS = body-part specific, CS = condition specific, (p) = if an instrument partly measured other aspects in addition to the main aspect, HRQoL = health-related quality of life domain, POF = physical & occupational function, PS = psychological state, SI = social interaction, SS = somatic sensation, ICF = International Classification of Functioning, FS = body function & body structure, A = activity and activity limitations, P = participation and participation restrictions, nd = not definable.

* Although specific terminology is not consistently applied in literature (19), we consider capacity (Cap) a subject's capability, ability or potential to carry out activities (can do), and performance (Perf) to be a subject's actual execution of activities (do do).

† It was impossible to classify ULAM outcome measures according to HRQoL domain because these domains represent functioning as subjectively perceived by the study population.

abbreviations are given in Table I. Furthermore, each instrument was assessed according to type of instrument, whether it measures performance and/or capacity aspects, the health-related quality of life domain(s) it covers, and the ICF levels their total scores cover (Table I). And finally, the individual outcome measures were categorized according to the main ICF concept they measure: body function & body structure, activity (limitations) or participation (restrictions).

Descriptive statistics and Spearman rank correlations were calculated (significance level $p \leq 0.05$). First, correlations were calculated between the ULAM outcome measures and the questionnaire total scores to determine the degree of relationship between the instruments. Data were checked on differences between subgroups (dominant hand involved, non-dominant hand involved). Then, inter-questionnaire correlations were calculated between the mutual questionnaire total scores to determine the relationship between the 4 questionnaires. In addition, correlations between the mutual ULAM outcome measures were calculated. Finally, it was established whether relationships differed depending on the ICF level.

RESULTS

The pattern of correlations was not different between the subgroups of dominant side and non-dominant side involved subjects, and therefore further analyses were performed on pooled data. Table II shows descriptive statistics for all 5 instruments. The generic questionnaires generally showed relatively small activity limitations and participation restrictions, and smaller limitations and restrictions than the body-part specific questionnaires.

Eleven of the 24 correlations (11/24, 46%) calculated between the ULAM outcome measures and the total scores of the questionnaires (Table III) were significant. Not one correlation coefficient exceeded 0.6 (0%). Of the 4 questionnaires, the DASH function symptoms score (DASH-fss) was most often significantly related to the generic and specific ULAM outcome measures. Five of the 6 inter-questionnaire correlations (5/6, 83%) were significant (Table IV); 3 of these 6 had a correlation coefficient higher than 0.6 (50%). The 2 ULAM generic outcome measures were significantly inter-related ($R_s = 0.92$, $p = 0.000$), as were the 4 ULAM body-part specific outcome measures ($0.53 < R_s < 0.93$). The correlations between the ULAM generic and ULAM body-part specific outcome measures were not significant ($0.03 < R_s < 0.26$).

For the outcome measures that mainly measure at the ICF activity level, there were more significant correlations between the generic ULAM outcome measures and the questionnaire outcome measures at this ICF activity level than between the body-part specific ULAM outcome measures and these questionnaire outcome measures (Table III). For the outcome measures that mainly measure at the ICF participation level, there were far less significant correlations between generic ULAM outcome measures and the questionnaire outcome measures at this ICF participation level than between body-part specific ULAM outcome measures and these questionnaire outcome measures (Table III).

Table II. *Descriptive statistics for all 5 instruments and their outcome measures*

Instrument & outcome measures		Possible range [best – worst functioning]	Mean score	Actual range
RASQ				
RASQ-tot		1–5	2.8	1.7–4.0
RASQ-pc		1–5	2.3	1.0–3.5
RASQ-da		1–5	3.2	1.8–4.2
RASQ-ra		1–5	4.1	1.0–5.0
RASQ-sa		1–5	2.4	1.0–5.0
RASQ-oi		1–5	2.6	1.0–4.7
RASQ-w		1–5	3.8	2.0–5.0
DASH				
DASH-fss		0–100	43.3	16.7–68.3
RAND-36/SF-36				
RAND36-tot[#] Nscores*		100–0	67.2	95.3–34.9
RAND36-pf	81.9	100–0	67.7	90.0–20.0
RAND36-sf	86.9	100–0	85.0	100.0–25.0
RAND36-prl	79.4	100–0	32.5	100.0–0.0
RAND36-erl	84.1	100–0	81.1	100.0–0.0
RAND36-mh	76.8	100–0	79.6	100.0–36.0
RAND36-vit	67.4	100–0	68.8	100.0–10.0
RAND36-bp	79.5	100–0	54.5	100.0–22.4
RAND36-ghp	72.7	100–0	68.7	90.0–20.0
SIP68				
SIP68-tot		0–68	9.1	1–22
SIP68-sa		0–17	0.8	0–5
SIP68-mc		0–12	2.8	1–8
SIP68-pa		0–11	1.1	0–10
SIP68-sb		0–12	3.2	0–7
SIP68-es		0–6	0.7	0–4
SIP68-mr		0–10	0.6	0–4
ULAM				
ULAM-%dyn		†	11.3	3.1–24.0
ULAM-body		†	2.3	0.8–4.5
ULAM-isit		†	3.1	1.5–5.2
ULAM-istand		†	10.0	4.5–17.4
ULAM-%sit		†	29.2	13.3–46.6
ULAM-%stand		†	73.0	40.1–89.1

[#] An unweighted mean across all 8 RAND36 outcome measure scores was used as additional outcome measure. However, the RAND36 "change in health" score was not taken into account in this chronic CRPSI population which explains the 35 items for RAND36-tot.
* These are the population mean norm scores of a Dutch population for the RAND36 outcome measures (26).
† The possible range is not specified for ULAM scores because the theoretical range for outcome measures involving percentages is from 100 to 0%, whereas this range is from ∞ to 0 g for outcome measures involving intensity. For each ULAM outcome measure, a higher score refers to better functioning.
For abbreviations see Table 1.

DISCUSSION

Although the body-part specific questionnaires indicated worse problems with functioning than the generic questionnaires, these 30 chronic upper limb CRPSI subjects did not generally perceive their functioning as very limited or restricted. Descriptive statistics were in accordance with other studies (14, 15, 25); most SIP68 outcome measures had little value in upper limb CRPSI and only a few RAND36 outcome measures were worse than the Dutch norm population (26).

The aim of this study was to determine the area of the ULAM in measuring functioning and health in upper limb complex regional pain syndrome type I compared with other instruments. Therefore we examined the relationships between several outcome measures. We realize that, in particular, our "correlation threshold" of 0.6 is arbitrary, but the level of the threshold does not influence the conclusions drawn. The same statement can be made about the number of correlation coefficients calculated without using, for example, Bonferoni correction. Of course, one must be careful in interpreting specific significant relationships, but the present study mainly focused on (comparison of) the strength and number of relationships, and Bonferoni correction would not substantially add to this.

The data clearly showed that the relationships between ULAM and questionnaire outcome measures were generally non-significant or weak, whereas significant and stronger relationships were more often found between questionnaire scores. This indicates that the ULAM differs from questionnaires, with the difference between measuring actual behaviour and

Table III. *Spearman rank correlations (and p-values) between Upper Limb Activity Monitor (ULAM) outcome measures and the questionnaire total score and individual outcome measures*

Instrument & outcome measures	Generic		Body-part specific			
	ULAM-%dyn	ULAM-body	ULAM-isit	ULAM-%sit	ULAM-istand	ULAM-%stand
RASQ-tot	0.30 (0.106)	0.30 (0.109)	0.48* (0.008)	0.41* (0.025)	0.32 (0.084)	0.15 (0.431)
RASQ-pc	0.25	0.28	0.45*	0.39*	0.37*	0.16
RASQ-da	0.24	0.19	0.37*	0.33	0.27	0.17
RASQ-ra	0.34	0.30	0.53*	0.43*	0.31	0.10
RASQ-sa	0.26	0.27	0.32	0.22	0.26	0.05
RASQ-oi	0.32	0.32	0.27	0.26	0.06	0.03
RASQ-w	0.59*	0.46	0.74*	0.74*	0.42	0.46
DASH-fss	0.41* (0.025)	0.36* (0.048)	0.48* (0.007)	0.45* (0.012)	0.17 (0.365)	0.03 (0.866)
RAND36-tot	0.23 (0.230)	0.09 (0.633)	0.57* (0.001)	0.53* (0.003)	0.43* (0.019)	0.28 (0.139)
RAND36-pf	0.41*	0.30	0.19	0.10	0.00	0.21
RAND36-sf	0.03	0.01	0.60*	0.64*	0.57*	0.45*
RAND36-prl	0.07	0.03	0.04	0.02	0.10	0.17
RAND36-erl	0.04	0.11	0.27	0.25	0.53*	0.29
RAND36-mh	0.40*	0.31	0.43*	0.39*	0.32	0.16
RAND36-vit	0.20	0.15	0.69*	0.64*	0.48*	0.41*
RAND36-bp	0.29	0.17	0.49*	0.48*	0.34	0.19
RAND36-ghp	0.30	0.16	0.42*	0.38*	0.23	0.28
SIP68-tot	0.38* (0.041)	0.29 (0.122)	0.38* (0.039)	0.36 (0.053)	0.17 (0.374)	0.01 (0.978)
SIP68-sa	0.48*	0.46*	0.38*	0.41*	0.18	0.09
SIP68-mc	0.68*	0.59*	0.27	0.23	0.04	0.18
SIP68-pa	0.05	0.07	0.15	0.23	0.06	0.03
SIP68-sb	0.09	0.02	0.45*	0.35	0.40*	0.23
SIP68-es	0.13	0.09	0.25	0.26	0.22	0.09
SIP68-mr	0.61*	0.55*	0.35	0.32	0.13	0.10

* Significant correlations ($p < 0.05$). Please note that the absolute values of the correlation coefficients are shown and that *p*-values are only given for the total scores.
For abbreviations see Table 1.

Table IV. *Spearman rank inter-questionnaire correlations between the total questionnaire scores and their respective p-values. Please note that the absolute values of the correlation coefficients are shown*

Spearman R_s × *p*-value	Body-part specific		Generic	
	RASQ-tot	DASH-fss	RAND36-tot	SIP68-tot
RASQ-tot	X	0.74	0.36	0.53
DASH-fss	0.000	X	0.43	0.68
RAND36-tot	0.053	0.018	X	0.64
SIP68-tot	0.003	0.000	0.000	X

measuring perceived functioning probably being the most important. The difference or discrepancy between these 2 aspects of functioning is described in the literature, e.g. healthcare professionals do not always agree with patients when it concerns their self-perceived functioning (27, 28).

In addition to this general analysis, we looked in more detail at the individual outcome measures and their relationships. For example, we classified the ULAM measures and the 4 questionnaires as generic or body-part specific. It was expected that mutual correlations between outcome measures of the same class would be relatively strong. This was only true for the generic ULAM-%dyn correlation with SIP68-tot, however. One of the factors that may explain this finding is that the generic ULAM measures differ considerably from the generic questionnaire outcome measures in other aspects. For example, there is more similarity with respect to HRQoL domains between SIP68-tot and generic ULAM measures than between generic ULAM measures and RAND36-tot. Furthermore, the RAND36-tot is generally more aimed at measuring ICF participation level (and beyond) than activity level. Finally, both ULAM and SIP68 score the subject's performance rather than their capacity, whereas the RAND-36 clearly stresses capacity. Apparently, the more characteristics generic questionnaires have in common with generic ULAM measures, the stronger the correlations. This conclusion is additionally supported by significant correlations between the some generic items containing DASH-fss and the 2 generic ULAM outcome measures vs the correlations between the plain body-part specific RASQ-tot and these ULAM outcome measures (only RASQ-w was significantly correlated). With the same type of reasoning it was expected that the DASH-fss would be more strongly correlated with body-part specific ULAM outcome measures than with generic ULAM outcome measures. This was true, but only for the ULAM body-part specific outcome measures during sitting. Since subjects with upper limb CRPSI were investigated, the correlations between mutual body-part specific outcome measures were of primary importance and expected to be significant. Hence, it was striking that the correlations between body-part specific questionnaire outcome measures were far more often significant

and stronger correlated with the ULAM outcome measures during sitting, whereas only 1 outcome measure (RASQ-pc) was significant during standing. This unexpected finding was reinforced by the proportion of questionnaire items; far more items describe upper limb activity during standing than during sitting, which would lead one to expect opposite results. Although it has been shown that the impact of upper limb CRPSI on ULAM outcome measures was somewhat greater during sitting than during standing (8), unfortunately this cannot adequately explain the present findings.

An important factor still to be discussed is the ICF level. Classification of questionnaire outcome measures according to the ICF resulted in a remarkable pattern of correlations between the ULAM and questionnaires. The very few significant correlations between generic ULAM outcome measures and questionnaire outcome measures at the participation level is most probably due to differences in ICF level. The strikingly much larger number of significant correlations between questionnaire outcome measures at the participation level and ULAM outcome measures *during standing* was difficult to explain because both groups of outcome measures have major differences with regard to type of instrument, ICF level, and problems with functioning (ULAM is body-part specific, at activity level and shown to be limited in CRPSI (8), whereas questionnaires were generic, at participation level, and not perceived as limited). It may be that when subjects are questioned about their functioning, aspects of activity and of participation and even beyond (i.e. HRQoL) are taken into account, whether subjects realize this or not. Such latter aspects of course cannot be measured with the ULAM, but may perhaps to some degree be reflected in its outcome measures. The concept activity is generally less broadly defined than the concept participation (29, 30), which was also confirmed by the present inter-questionnaire correlations. Questionnaire outcome measures at the activity level were more often significantly inter-related than the questionnaire outcome measures at the participation level.

It should be noted that the ULAM also has some limitations that may affect methodological quality (6–8, 31). For example, the current ULAM does not validly measure fine upper limb motor skills and holding of objects and is therefore a rather rough outcome measure. Another possible limitation related to (test-retest-)reliability is the "between-day variance of upper limb activity". Although there certainly are some differences in methodological quality (reliability and validity aspects) between the presently used questionnaires, it is clear that their methodological strengths and weaknesses can be compared. In contrast, the aspects of methodological quality of the ULAM are less easily applicable to questionnaires and the ULAM can therefore only in part be compared with the questionnaires, which may also explain the ambiguous relationships between ULAM and questionnaire outcome measures.

Finally, it is important to realize that the present findings should not be confused with the idea that the ULAM is a new reference method and that measurement of what a person really does during everyday life is most important. The ULAM should be regarded as an addition to other techniques; however, we agree with others (32–34) that the choice for an instrument should always depend on a complexity of factors, including clinical problem, research question and study design, activity aspects of interest, and cost and availability of instruments (3).

In conclusion, the relationships between ULAM and questionnaire outcome measures were generally non-significant or weak, whereas more often significant and stronger relationships were found between questionnaire scores. The ULAM measures similar aspects of functioning only to a certain extent, and it measures – at least partly – different areas of functioning and health. The more characteristics the ULAM has in common with other instruments, the stronger and more often significant relationships were found.

REFERENCES

1. Liang MH, Lew RA, Stucki G, Fortin PR, Daltroy L. Measuring clinically important changes with patient-oriented questionnaires. Med Care 2002; 40: II45–51.
2. WHO. International Classification of Functioning, Disability and Health: ICF. Geneva: World Health Organization; 2002.
3. Bussmann JBJ, Stam HJ. Techniques for measurement and assessment of mobility in rehabilitation medicine: a theoretical approach. Clin Rehabil 1998; 12: 513–522.
4. Cieza A, Brockow T, Ewert T, Amman E, Kollerits B, Chatterji S, et al. Linking health-status measurements to the International classification of functioning, disability and health: an introduction and discussion of its potential impact on rehabilitation services and research. J Rehabil Med 2002; 34: 205–210.
5. Keith RA. Functional status and health status. Arch Phys Med Rehabil 1994; 75: 478–483.
6. Schasfoort FC, Bussmann JB, Stam HJ. Ambulatory measurement of upper limb usage and mobility-related activities during normal daily life with an upper limb-activity monitor: a feasibility study. Med Biol Eng Comput 2002; 40: 173–182.
7. Bussmann JBJ, Martens WLJ, Tulen JHM, Schasfoort FC, Berg-Emons HJGvd, Stam HJ. Measuring daily behaviour using ambulatory accelerometry: the Activity Monitor. Behavior Research Methods, Instruments & Computers 2001; 33: 349–356.
8. Schasfoort FC, Bussmann JBJ, Zandbergen AMAJ, Stam HJ. Impact of upper limb complex regional pain syndrome type I on everyday life measured with a novel upper limb-activity monitor. Pain 2003; 101: 79–88.
9. Stanton-Hicks M, Janig W, Hassenbusch S, Haddox JD, Boas R, Wilson P. Reflex sympathetic dystrophy: changing concepts and taxonomy. Pain 1995; 63: 127–133.
10. Manning DC. Reflex sympathetic dystrophy, sympathetically maintained pain, and complex regional pain syndrome: diagnoses of inclusion, exclusion, or confusion? J Hand Ther 2000; 13: 260–268.
11. Bruehl S, Harden RN, Galer BS, Saltz S, Bertram M, Backonja M, et al. External validation of IASP diagnostic criteria for Complex Regional Pain Syndrome and proposed research diagnostic criteria. International Association for the Study of Pain. Pain 1999; 81: 147–154.
12. Kemler MA, Furnee CA. The impact of chronic pain on life in the household. J Pain Symptom Manage 2002; 23: 433–441.
13. Oerlemans HM, Cup EH, DeBoo T, Goris RJ, Oostendorp RA. The Radboud skills questionnaire: construction and reliability in patients with reflex sympathetic dystrophy of one upper extremity. Disabil Rehabil 2000; 22: 233–245.
14. Geertzen JH, Dijkstra PU, Groothoff JW, ten Duis HJ, Eisma WH. Reflex sympathetic dystrophy of the upper extremity – a 5.5-year

follow-up. Part II. Social life events, general health and changes in occupation. Acta Orthop Scand Suppl 1998; 279: 19–23.
15. Geertzen JH, Dijkstra PU, van Sonderen EL, Groothoff JW, ten Duis HJ, Eisma WH. Relationship between impairments, disability and handicap in reflex sympathetic dystrophy patients: a long-term follow-up study. Clin Rehabil 1998; 12: 402–412.
16. Schasfoort FC, Bussmann JB, Stam HJ. Outcome measures for complex regional pain syndrome type I: an overview in the context of the international classification of impairments, disabilities and handicaps. Disabil Rehabil 2000; 22: 387–398.
17. Veldman PH, Reynen HM, Arntz IE, Goris RJ. Signs and symptoms of reflex sympathetic dystrophy: prospective study of 829 patients. Lancet 1993; 342: 1012–1016.
18. Oerlemans HM, Oostendorp RA, de Boo T, van der Laan L, Severens JL, Goris JA. Adjuvant physical therapy versus occupational therapy in patients with reflex sympathetic dystrophy/complex regional pain syndrome type I. Arch Phys Med Rehabil 2000; 81: 49–56.
19. Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand) [corrected]. The Upper Extremity Collaborative Group (UECG). Am J Ind Med 1996; 29: 602–608.
20. Veehof MM, Sleegers EJ, van Veldhoven NH, Schuurman AH, van Meeteren NL. Psychometric qualities of the Dutch language version of the Disabilities of the Arm, Shoulder, and Hand questionnaire (DASH-DLV). J Hand Ther 2002; 15: 347–354.
21. VanderZee KI, Sanderman R, Heyink J. A comparison of two multidimensional measures of health status: the Nottingham Health Profile and the RAND 36-Item Health Survey 1.0. Qual Life Res 1996; 5: 165–174.
22. Ware JE, Jr., Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. Med Care 1992; 30: 473–483.
23. Bergner M, Bobbitt RA, Carter WB, Gilson BS. The Sickness Impact Profile: development and final revision of a health status measure. Med Care 1981; 19: 787–805.
24. de Bruin AF, Diederiks JP, de Witte LP, Stevens FC, Philipsen H. Assessing the responsiveness of a functional status measure: the Sickness Impact Profile versus the SIP68. J Clin Epidemiol 1997; 50: 529–540.
25. Kemler MA, de Vet HC. Health-related quality of life in chronic refractory reflex sympathetic dystrophy (complex regional pain syndrome type I). J Pain Symptom Manage 2000; 20: 68–76.
26. VanderZee KI, Sanderman R. Het meten van de algemene gezondheidstoestand met de RAND-36: een handleiding (Dutch). In: Noordelijk Centrum voor Gezondheidsvraagstukken, NCG, reeks meetinstrumenten; 3. Groningen; 1993.
27. Fowler FJ, Jr., Cleary PD, Magaziner J, Patrick DL, Benjamin KL. Methodological issues in measuring patient-reported outcomes: the agenda of the Work Group on Outcomes Assessment. Med Care 1994; 32: JS65–JS76.
28. Grimby A, Wiklund I. Health-related quality of life in old age. A study among 76-year-old Swedish urban citizens. Scand J Soc Med 1994; 22: 7–14.
29. Badley EM. An introduction to the concepts and classifications of the international classification of impairments, disabilities, and handicaps. Disabil Rehabil 1993; 15: 161–178.
30. Brandsma JW, Lakerveld-Heyl K, Van Ravensberg CD, Heerkens YF. Reflection on the definition of impairment and disability as defined by the World Health Organization. Disabil Rehabil 1995; 17: 119–127.
31. Schasfoort FC, Bussmann JBJ, Stam HJ. Impairments and activity limitations in patients with upper limb Complex Regional Pain Syndrome type I. Arch Phys Med Rehabil. 2004; 85: 557–566.
32. Ware JE, Jr., Brook RH, Davies AR, Lohr KN. Choosing measures of health status for individuals in general populations. Am J Public Health 1981; 71: 620–625.
33. Beaton DE, Hogg-Johnson S, Bombardier C. Evaluating changes in health status: reliability and responsiveness of five generic health status measures in workers with musculoskeletal disorders. J Clin Epidemiol 1997; 50: 79–93.
34. Bombardier C, Tugwell P. Methodological considerations in functional assessment. J Rheumatol 1987; 14 (suppl 15): 6–10.