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Joint flexibility problems and the impact of its operationalisation

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ABSTRACT

Background: Dissatisfaction is being voiced with the generally used way joint flexibility problems are defined (operationalised), i.e. as a range of motion (ROM) one or more degrees lower than normative ROM of healthy subjects. Other, specifically more function-related operationalisations have been proposed. The current study evaluated the effect of applying different operationalisations of joint flexibility problems on its prevalence.

Method: ROM data of 95 joints affected by burns of 23 children were used, and data on 18 functional activities (Burn Outcome Questionnaire (BOQ)). Five methods were used to operationalise joint flexibility problems: (1) ROM below normative ROM, (2) ROM below normative ROM minus 1SD, (3) ROM below normative ROM minus 2SD, (4) ROM below functional ROM, and (5) a score of 2 or more on the Likert Scale (BOQ).

Results: Prevalence of joint flexibility problems on a group level ranged from 13 to 100% depending on the operationalisation used. Per joint and movement direction, prevalence ranged from 40% to 100% (Method 1) and 0% to 80% (Methods 2–4). 18% of the children received '2' on the Likert Scale (Method 5).

Conclusion: The operationalisation of joint flexibility problems substantially influences prevalence, both on group and joint level. Changing to a function-related operationalisation seems valuable; however, international consensus is required regarding its adoption.

Abbreviations: ADL, activities of daily living; TBSA, total body surface area; BOQ, burns outcome questionnaire; ROM, range of motion.

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1. Introduction

Joint flexibility is immensely important for the performance of activities of daily living (ADL) [1–3]. Burn injuries as well as many neurological and orthopaedic conditions, however, can affect joint flexibility [4]. The usual way to translate a joint flexibility problem into a measurable variable is to compare the measured range of motion (ROM) of a specific joint and movement direction with the normative ROM value, i.e. the mean maximal ROM of healthy subjects [5–8]. According to this operationalisation, a measured ROM of one or more degrees lower than the normative ROM is defined as a joint flexibility problem [9–15]. This normative ROM operationalisation of joint flexibility problems is leading in registration and research. It is used to determine the prevalence of joint flexibility problems and to compare and evaluate the outcome of treatment and care over time and between different health care centres [16]. In clinical practice however, the patient, common sense, and experience determines when a limited joint flexibility is a risk or a problem, specifically in terms of function. It can be strongly doubted therefore, whether the most often used normative ROM operationalisation of joint flexibility problems is the most suitable, especially as it obviously does not reflect clinical practice.

What are the alternatives? One is following the reasoning of the World Health Organization (WHO) on their operationalisation of the problem of obesity in children. In that case, a distinction is made between 'no weight problem', 'at risk for obesity', and 'obese' whereby between one and two standard deviations (SD) above the median body mass index is defined as 'at risk' and more than 2SD above the median is 'obese' [17]. Using this reasoning for the operationalisation of joint flexibility problems would mean that a measured ROM between one SD and two SD below the normative value means 'at risk' for joint flexibility problems and more than 2SD below the normative value indicates a 'joint flexibility problem'.

Another alternative for the operationalisation of joint flexibility problems is in terms of function, i.e., defining a joint flexibility problem by comparing a measured ROM to the ROM necessary for functioning. Functional ROM is the ROM that healthy subjects actually use for performing activities of daily living. Throughout the years, this alternative has been advocated in the literature on burn contractures [9,15,16,18–21]. A prerequisite for applying this operationalisation is knowing the functional ROM of all joints and movement directions. Recently, Korp et al. [20] made a start in making such data accessible through a review of the literature [20], and our detailed systematic review of the literature extends the information, specifically concerning the shoulder and elbow [22].

Finally, besides the ROM based operationalisations, an alternative is to evaluate joint flexibility problems in terms of whether a person experiences difficulties in daily living, assessed by patient-report outcome measures.

Clearly, different operationalisations of joint flexibility problems are possible. The aim of the present study was to demonstrate the effect of using different operationalisations of joint flexibility problems on its prevalence.

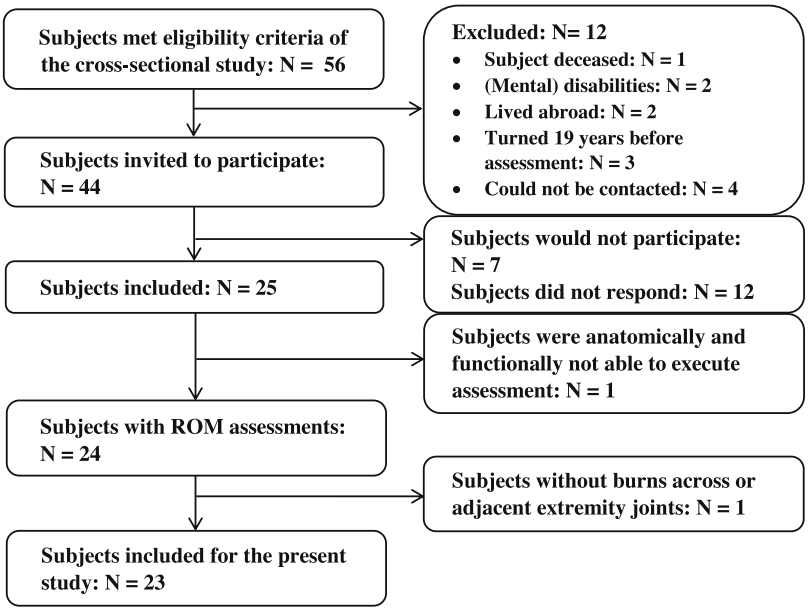

Fig. 1 – Flow chart of subject enrolment.

2. Method

In the present study, the STROBE guidelines for reporting were used [23].

2.1. Study and subject characteristics

Data were collected between October and November 2012 as part of the cross-sectional study of Disseldorp et al. [12] (National Academic Research and Collaborations Information System of the Netherlands number: OND1348800; The Medical Ethical Committee of University Medical Centre Groningen approved this study: NL40183.042.12) [24]. The total cohort study comprised the assessment of exercise capacity (incremental maximal exercise test on an electronically braked cycle ergometer), body composition (body mass index, waist circumference and skinfold thickness), muscular strength (hand-held dynamometer), and joint range of motion (goniometer). Assessments were done in a mobile exercise lab near to the subjects home by two researchers (LMD, AMO). Physical activity and sedentary behavior were assessed by accelerometry during one week and questionnaires (Dutch Standard Questionnaire for Activity, Subscale FIT Norm. subscale Dutch Activity Norm). Furthermore, questionnaires were used to assess perceived fatigue (PedsQL Multidimensional Fatigue Scale) and health-related quality of life (Burn Outcome Questionnaire (BOQ)). Included were 24 children (6–18 years old) that had been admitted to a Dutch burn centre with >10% Total Body Surface Area (TBSA) burned, a length of stay of more than six weeks, or both, and the burn injury having occurred between six months and five years before measurement. Excluded were subjects with (pre-existing) comorbidity, (mental) disabilities or insufficient Dutch language proficiency. Written informed consent was provided by all parents (or legal representatives) as well as by subjects aged ≥12 years before enrolment; for subjects aged 18 parental informed consent was not required. The subject enrolment is described in Fig. 1. The subject and burn characteristics are described including the extent and depth of the burn, location of burn, length of stay at the hospital, and surgery (Table 1 and 4).

2.2. Collection of ROM and functional outcome data

In the present study, ROM data and scores on the 18 items of the BOQ were used. Passive ROM was measured in degrees according to the standardized protocol described by Klerks et al. [7] using a goniometer (Gollehon extendable goniometer 01135, Lafayette Instrument, Lafayette, U.S.A.). Goniometry has shown to be reliable for the assessment of joint ROM in patients with burns [25]. ROM was measured in the shoulder (flexion), elbow (flexion and extension), wrist (dorsal and palmar flexion), knee (flexion and extension), and ankle (plantar and dorsal flexion) on the dominant side of the body. In the event that there were burn scars across or adjacent to a specific joint, this joint was measured on both sides of the body [24], except if no evident burn scar was seen at time of measurement. Being adjacent to a joint was defined as a burn at a maximum distance of 1/3 of the length of the adjoining body part/limb.

The presence and severity of functional problems were subjectively scored on the 18 functional items of the validated Dutch version of the American Burn Association/ Shriners' Hospital Children Burn Outcome Questionnaire. These 18 items comprise questions on upper extremity function (seven items), physical function/sports (six items), and

Table 1 – Subject and burn characteristics.

Characteristics	N	%	Mean ± SD	Median	IQR	Mode	Range
Number of children included	23						
Age at injury (years)			7.5 ± 4.3	8	6	8	1–16
Age at assessment (years)			10.6 ± 3.8	9	5.5	7	6–18
Time between injury and assessment (years)			3.0 ± 1.1	3	1.4	2.8	1–5
Male subjects	14	61%					
% TBSA burned			18.2 ± 8.4	16	9.8	10	10–41
<20%	16	70%					
≥20%, <30%	4	17%					
≥30%	3	13%					
Full thickness burns (%TBSA)			6.1 ± 9.0	2	8	0	0–41
Subjects with arm burns	18	78%					
Subjects with leg burns	14	61%					
Length of hospital stay (days)			29.2 ± 13.6	24	9.5	24	16–78
≤3 weeks	5	22%					
>3 weeks, ≤4 weeks	12	52%					
>4 weeks, ≤5 weeks	1	4%					
>5 weeks	5	22%					
Number of children with surgery	21	91%					
Number of surgeries			1.7 ± 1.5	1	1	1	0–7
Number of children with reconstructive surgery[a]	5	22%					
Number of reconstructive surgeries[a]			0.4 ± 0.8	0	0	0	0–3

IQR: Interquartile range between Q1 and Q3.
[a] Reconstructive surgeries before time of assessment.

Table 2 – Cut-off values for ROM per joint and movement direction used for the operationalisation of joint flexibility problems.

Method	Shoulder flexion	Elbow flexion	Elbow extension[c]	Wrist palmar flexion	Wrist dorsal flexion	Knee flexion	Knee extension[c]	Ankle plantar flexion	Ankle dorsal flexion
1) Normative values[a]	180°	154°	10°	108°	97°	155°	7°	62°	24°
2) Normative values[a] minus 1* SD	166°	148°	4°	94°	87°	149°	3°	51°	16°
3) Normative values[a] minus 2* SD	152°	142°	−2°	80°	77°	143°	−1°	42°	8°
4) Functional ROM[b]	142°	152°	−1°	54°	63°	138°	0°	32°	36°

[a] Age matched Dutch normative values of Klerks et al. [7].
[b] Functional ROMs of Oosterwijk et al. [22] for shoulder and elbow; functional ROMs of Korp et al. for wrist, knee, ankle [20].
[c] A positive number for extension means hyperextension; when the zero-position cannot be performed (elbow or knee completely straight), the limitation is described with a minus sign.

Table 3 – Prevalence (%) of joint flexibility problems in children 1–5 years after burn as calculated with 5 different methods.

Method		N assessed	N with joint flexibility problem(s)	Prevalence (%) of joint flexibility problems
1	ROM < Normative value[a]	23	23	100%
2	ROM < Normative value[a] minus 1* SD	23	10	43%
3	ROM < Normative value[a] minus 2* SD	23	3	13%
4	ROM < Functional ROM[b]	23	14	61%
5	BOQ	22	4	18%

[a] Age matched Dutch normative values of Klerks et al. [7].
[b] Functional ROMs of Oosterwijk et al. for shoulder and elbow [22]; functional ROMs of Korp et al. for wrist, knee, ankle [20].

Table 4 – Prevalence (%) of joint flexibility problems in 23 subjects per movement direction per joint according to Methods.1–4.

Joints (N burned)	Shoulder (23)	Elbow (20)		Wrist (18)		Knee (24)		Ankle (10)	
Movement direction	Flexion	Flexion	Extension	Palmar flexion	Dorsal flexion	Flexion	Extension	Plantar flexion	Dorsal flexion
1 ROM < Normative value[a]	100%	70%	45%	44%	44%	50%	50%	40%	40%
2 ROM < Normative value[a] minus 1*SD	9%	15%	20%	0%	17%	8%	8%	0%	10%
3 ROM < Normative value[a] minus 2*SD	0%	10%	5%	0%	0%	4%	0%	0%	0%
4 ROM < Functional ROM[b]	0%	55%	5%	0%	0%	0%	0%	0%	80%

[a] Age matched Dutch normative values of Klerks et al. [7].
[b] Functional ROMs of Oosterwijk et al. for shoulder and elbow [22]; functional ROMs of Korp et al. for wrist, knee and ankle [20].

transfers/mobility (five items) during activities of daily living [24,26,27]. The presence and severity of a functional problem was scored per activity on a 4-point Likert Scale except for 'How often does this child/do you need help from another person for walking and climbing', which was scored on a 5-point Likert Scale. A higher score on the Likert Scale reflects a child having more difficulties in performing an activity, i.e. on the 4-point Likert scale a score of '1' means 'easy', '2' means 'a little hard', '3' means 'very hard', '4' means 'can't do'; on the 5-point Likert scale a score of '1' means 'never', '2' means 'sometimes', '3' means 'about half of the time', '4' means 'often', '5' means 'all of the time'. The BOQ has a parental proxy and adolescent version. The parental proxy version was used for the children of 6–11 years of age and the adolescent version for those aged 12–18 years old.

2.3. *Different operationalisations of joint flexibility problems*

Joint flexibility problems were determined based on five different operationalisations. A joint flexibility problem was operationalised as being present when the measured ROM was (1) one degree or more below the age matched Dutch normative value [14]; (2) one SD below these normative values; (3) two SD below these normative values; or (4) below the functional ROM. For functional ROM, data from Korp et al. [20] were used regarding the wrist, knee, and ankle joints [9] and from Oosterwijk et al. [22] regarding the shoulder and elbow joints [11]. These cut-off points are reflecting the ROM that is used by healthy subjects to complete ADL tasks without compensatory movements (Table 2). Finally, joint flexibility

problems were operationalised as being present if: (5) a score of 2 or more on the Likert scale on any of the 18 functional items of de BOQ was given.

2.4. Calculations of prevalences

Per operationalisation method, the prevalence of joint flexibility problems was calculated for the entire group of children, i.e., what percentage of them had a joint flexibility problem in any of the measured movement directions of a joint with a burn across or adjacent to it (Method 1–4). For experienced functional problems (Method 5), the prevalence was determined as the percentage of subjects that scored 2 or more on one or more of the 18 BOQ items.

Furthermore, the prevalence of joint flexibility problems was calculated per measured movement direction for Method 1–4, i.e., what percentage of this population had a joint flexibility problem in a specific movement direction per joint with a burn across or adjacent to it. This was not possible for Method 5 as problems are scored per functional activity on a Likert scale and are therefore not joint-specific.

Calculated prevalences were compared with each other in a descriptive analysis.

3. Results

In the 23 subjects included for the present study, there were 112 joints with a burn across or adjacent. For the present study, ROM data of 95 of these joints (85%) were included for calculating the prevalence of joint flexibility problems as the other joints had not been assessed as no burn scars were evident at the time of measurement. The BOQ data were available for 22 subjects: 14 for subjects 6–11 years old and eight for subjects 12–18 years old. For one subject (≥12 years old), the questionnaire was lost in the post and therefore not available for data-analysis.

3.1. Group level

3.1.1. Prevalence of joint flexibility problems per operationalisation method

The prevalence of joint flexibility problems on group level according to Method 1 was 100%, meaning that all of the 23 children were classified as having a problem in at least one movement direction of the upper or lower extremity. According to Methods 2 and 3, both based on the normative ROM but taking 1SD or 2 SD into account, resulted in a prevalence of joint flexibility problems of 43% and 13%, respectively. Prevalences calculated according to Methods 4 and 5, each taking function into account, were 61% and 18% respectively (Table 3).

3.1.2. Comparison of prevalences

Comparing the prevalences on group level exposed substantial differences. Prevalence was highest, by far, based on normative ROM without taking SD into account. None of the methods gave identical results to others, though the prevalences of the operationalisations ROM minus 2SD (Method 3) and the experienced functional outcome (Method 5) were rather similar (<20%).

3.2. Per movement direction per joint

3.2.1. Prevalences of joint flexibility per operationalisation method

Using Method 1, the prevalence of joint flexibility problems per movement direction per joint ranged from 40% for ankle plantar and dorsal flexion up to 100% for shoulder flexion (Table 4). For Methods 2 and 3, the prevalence per movement direction ranged from 0% to 20% and from 0% to 10%, respectively (Table 4). Regarding functional limitations (Method 4), the prevalence per joint ranged from 0% for the most movement directions to 80% for ankle dorsal flexion (Table 4).

Of four subjects (all ≤11 years), the parents scored that the performance of one or two functional tasks were 'a little hard' for their child (2 on the 4-point Likert Scale) (Table 5).

Performance of these tasks seemed to correspond with the location of the burns except in one subject whereby fastening buttons was 'a little hard' whereas the burns were located on the individual's legs (Table 5). However, clear relations between specific BOQ tasks and limitations in ROMs could not be made as not all joints that are required for the performance of the task were measured.

3.2.2. Comparison of prevalences

The comparison of prevalences per joint calculated with the different operationalisation methods showed a difference of ≥40% between the highest and lowest outcome for each movement direction. For shoulder flexion, this difference was 100% (Table 4). As expected, the prevalences from Method 3 were always lower than those from Method 2, which were

Table 5 – Problems in functional activities scored on the 4-point Likert Scale according to the BOQ by four subjects (Method 5).

Subject	Areas burned	Functional activities		
		Walking about 300 m	Turning the head to look over the shoulder	Fasting buttons
1	Back, neck dorsal, part of right upper arm, part of left upper leg	2	2	–
2	Chest, abdomen, neck ventral, part of back, part of both upper and lower arms, part of both upper legs, both hands	–	2	–
3	Both upper legs and part of left lower leg	–	–	2
4	Face, neck, part of back, both arms, hands and legs	–	–	2

On the 4-point Likert scale a score of '1' means 'easy', '2' means 'a little hard', '3' means 'very hard' and '4' means 'can't do'.

subsequently always lower than those of Method 1. However, the absolute differences between these three methods were different per movement direction (Table 4). For almost all movement directions, lower prevalences were indicated according to the functional ROM (Method 4) in comparison with those of normative ROM (Method 1) (Table 4).

Although analysing the functional problems that were experienced (Method 5) is not possible on the level of movement direction per joint, it can be concluded that the results according to Method 5 were not in line with the results according to Method 1. Four parents scoring 'a little hard' (2 on the 4-point Likert scale) was not conform a prevalence of joint flexibility problems ranging from 40% to 100% in all of the measured movement directions.

4. Discussion

In literature, dissatisfaction has been voiced with the most widely used operationalisation of a joint flexibility problem, i.e., a problem exists if a measured ROM in a specific movement direction of a joint is one or more degrees lower than the corresponding normative ROM of healthy subjects [9–11,14,18,19,28]. Therefore, in the present study we evaluated the effect of different, alternative operationalisations of joint flexibility problems in the light of prevalences using a ROM dataset of children that were studied one to five years after burn. The results of the present study showed that the different operationalisations substantially affected prevalences on both a group and joint level.

The call to abandon the normative ROM operationalisation for joint flexibility problems because of a lack of clinical relevance has a long history, especially in the literature on burn injuries [9–11,14,18–20,28], and we agree with and support this call. In our opinion, the normative ROM operationalisation (i.e. one degree or more below the normative value) of a joint flexibility problem should be abandoned as it leads to clinically irrelevant high prevalences. In the present study, we evaluated also the other normative ROM derived operationalisations (below 1SD or 2SD of normative ROM). At first, the 1SD method appeared to be a suitable option when comparing prevalence outcomes of this method with function based outcomes on a group level. However, the results per movement direction per joint demonstrated that the 1SD method neglected the substantial differences in functional ROM per joint.

To make prevalence outcomes of joint flexibility problems relevant for evaluation of clinical care, we are convinced that the most fitting alternative is a function related operationalisation whereby two options are available, i.e., a subjective and an objective one with a combination of both most likely being superior.

Solely a subjective operationalisation is not the solution for the following reasons. First, when the ROMs of multiple joints of a coordinated joint system are limited, the functional problems on a specific joint level are not detectable with a questionnaire. Second, as compensatory movements in other components of the coordinated joint system can be used to accomplish activities, the impact of a joint flexibility problem can be underestimated by the subject [29–32]. In the present study, the latter could possibly explain the difference in prevalence per group using the functional ROM method (61%) (Method 4) and the scored functional problems (18%) (Method 5) as many functional tasks with the upper extremities can be accomplished unilaterally or with (over)use of other joints. In the long term, overuse can cause physical problems depending on how often, for how long, and at which angle these compensatory movements are used. Third, the outcome of a questionnaire is subjective and therefore, besides a limitation in joint flexibility, factors such as pain or fear to move could also influence the problems that are experienced.

Hence, we argue for an operationalisation of a joint flexibility problem in terms of a functional ROM and combine this with a patient-report outcome measure. At this moment, the combined functional ROMs of Korp et al. [20] and Oosterwijk et al. [22] are the best there are. However, many activities are not yet covered including almost all dressing tasks and no distinction is made between age groups. Therefore, this still requires additional work.

Apart from the discussion regarding operationalisation of joint flexibility problems, we would like to briefly draw attention to the way ROM is measured, i.e., the goniometer. Whereas it is the most commonly used, economical, and portable device to measure ROM [33], and has been found to be reliable in patients with burns [25]. Other reports however, question its reliability [34,35], and moreover, the minimal detectable difference is high [25]. Therefore, efforts should be made to develop a feasible, affordable, and especially more reliable instrument.

5. Limitations

The used data set was not large; 95 joints in 23 children assessed at various time points after burn. However, for our purpose, it was well suited because of the large range in measured ROM between the children and joints.

Scoring on the 18 items of the BOQ is not the most optimal representative for a subjective scale to indicate flexibility problems in ADL. There are other scales more specifically designed for this. However, as the present data were part of a more comprehensive study in which many measures were already taken, the most relevant selection of the available data was used.

As previously mentioned, the combined functional ROMs of Korp et al. [20] and Oosterwijk et al. [22] are the best that are currently available, however, many activities are not yet addressed including almost all dressing tasks, and no distinction is made between age groups. Studies on functional ROM in children are still minimal and comprise only a limited number of tasks [1,36–39]. It is possible that the functional ROM for children differs from that of adults due to postural differences and differences in ADL tasks. Furthermore, it must be mentioned that subjects with a ROM lower than the functional ROM could still be able to complete ADL tasks with compensatory movements.

6. Further research

The essence of the present study is to encourage an internationally accepted clinically relevant operationalisation for joint flexibility problems. Research aiming at such

operationalisation could include a Delphi-study with experts of different burn centres, orthopaedic surgeons, physiotherapists and occupational therapists. Besides, if functional ROM is advocated, future research should focus on what tasks cover full ADL for different populations, for instance children, adults and elderly.

7. Conclusion

The outcomes of the prevalence of joint flexibility problems for the entire group and per movement direction differ substantially depending on the operationalisation of the joint flexibility problems that are used. This finding leads to the recommendation that international consensus is required on disregarding normative ROM based operationalisations of joint flexibility problems and adopting a new function-related operationalisation.

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