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What to Expect: Medical Quality Outcomes and Achievements of a Multidisciplinary Inpatient Musculoskeletal System Rehabilitation

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Additional information is available at the end of the chapter

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Abstract

The incidence of chronic diseases is rising. Rehabilitation plays a vital role in preventing and minimizing the functional limitations associated with chronic conditions and aging. Routine outcome measures include disease-specific and unspecific general health parameters. This study evaluates indicators for medical quality outcomes from 10,373 patients (61.00 ± 13.65 years, 51.7% women) who have undergone orthopedic rehabilitation for three weeks. Inpatient rehabilitation reduces lifestyle-related risk factors, optimizes organ functioning and improves the well-being in the majority of patients (81.3%; $SMD = 0.52 \pm 0.38$). Improvements of unspecific and indication specific outcome parameters can be observed in a comparable magnitude. However, disease specific and unspecific health factors are not directly related to each other ($r = 0.19$). Age, gender, ICD-classification and time of rehabilitation have an influence on initial values and on indication-specific medical outcomes but are insignificant with regards to improvements in unspecific medical outcome parameters. Inpatient rehabilitation includes two main pathways of medical practice, which can be clearly distinguished in terms of their therapeutic outcome. There are general health interventions, such as lifestyle modifications, diet and physical exercise, and symptom-specific treatments. So multidisciplinary medical rehabilitation improves general well-being and physical functioning as well as reduces risk factors in the majority of patients.

Keywords: inpatient rehabilitation, medical quality outcomes, routine outcome measurement, reference data, rehab success

1. Introduction

The definition of rehabilitation has become more transparent all over the world after the World Health Organization (WHO) published the five health strategies (promotion, prevention, cure, rehabilitation and palliative care) in rehabilitation [1]. Rehabilitation was previously understood as a heterogeneous approach. It was framed as a highly specialized service for athletes, a controlled training intervention or a post-injury service for return-to-work intervention. The definition was standardized through the WHO to a homogenous understanding of rehabilitation as a service to restore functioning, ameliorate the impact of the reduction in capacity and minimize further initial health problems in all stages of health provision [2].

Special care in rehabilitation is given to the ailments of the modern society. As such, especially risk factors like sedentary behavior¹, physical inactivity, overeating causing obesity, alcohol abuse and smoking leading to various chronic diseases that immediately affect the musculoskeletal system [3] are causes for concern. Due to those lifestyle choices that lead to potentially life-threatening conditions, physical activity has become an important therapeutic approach. It is a primary, secondary or tertiary therapeutic approach of chronic diseases over the last decades. Physical activity recommendations are now broadly understood as health-related interventions that propose a minimum dose of physical activity.

The WHO [1] suggests at least 150 minutes of moderate aerobic activity or 75 minutes of vigorous aerobic activity throughout the week for adults. In addition, muscle-strengthening activities should be done involving major muscle groups on two or more days a week and sedentary behavior should be reduced. Small amounts of physical activity already have a positive impact on the health status; however, the strongest effect can be observed in adults that transformed from an inactive to an active lifestyle [4–6].

Medical intervention programs therefore do not only aim to restore physiological functioning, reverse or undo the damage caused by disease or injury, but also rather to optimize the health status by improving strength and aerobic capacity. The amelioration of the physical constitution leads to health-promoting effects like the reduction of high blood pressure, a better glucose profile and reduced blood lipids [7, 8]. Physical activity has a positive impact not only on metabolic and cardiovascular diseases but also on the musculoskeletal system.

Complaints of the musculoskeletal system are most commonly those of inflammatory and degenerative origin. These origins of disease are the cause for chronic pain, painful functional impairment and a reduced quality of life worldwide. Rheumatoid arthritis is found in 3.2% of women and 1.9% of men. Furthermore, another increasing ailment is osteoporosis, which is found in 3.1% of women and 1.9% of men, with a high prevalence from the age of 80 onwards [9].

¹For example, through (screen) workplaces and automation, leisure activities such as video games, social media and television.

The most common symptom of the musculoskeletal system is back pain (60–80% long-time prevalence [10, 11]). The prevalence is dependent on age, with a rise of prevalence with age. The highest prevalence for back pain is set between 40 and 69 years; women are more affected than men [12, 13].

The findings of an analysis by the Austrian Health Survey 2014 [14] report an estimated rate of 24% (about 1.8 Mio individuals) suffering from chronic back pain. Furthermore, 19% claimed about discomfort of the cervical spine. The cervical spine complaint was gender dependent (23% women versus 14% men). Arthrosis was found in 15% of women and 8% of men. The gender difference refers not only to the frequency of the disease but also to the pain perception, due to a higher rate of female pain sensitivity, lower threshold for pain and a lower suspension of pain [15].

Due to the high prevalence of degenerative diseases of the musculoskeletal system, there is also a demand for surgical treatment with endoprosthesis material. The highest operative treatment rates for such procedures worldwide are found in Switzerland, Germany and Austria. In Germany, about 230,000 hip, 170,000 knee and 25,000 shoulder endoprosthesis surgeries were performed in the year 2011 alone [16].

Physiotherapy and physical activity are fundamental components for the process of recovery. The body of available knowledge confirms positive effects of physiotherapy and physical activity throughout all organ systems. It reduces swelling as well as promotes building strength and aerobic capacity. Through the process of physiotherapy and physical activity interventions, a total physiological functionality after surgical treatment can be achieved. Moderate physical activity reduces the risk of osteoporosis and improves the osseointegration of bone substitutes. Almost all musculoskeletal diseases can be treated by therapies including physical activity and strengthening programs [17–20]. Physical activity thus has become the gold standard among medical treatments.

1.1. Orthopedic rehabilitation

Following the WHO definition, the rehabilitative process can be divided into four phases: phase I includes the early mobilization in primary treatment, phase II provides follow-up treatments or post-acute therapy in rehabilitation centers, phase III tries to integrate and stabilize the long-term life modifications and phase IV deals with long-term rehabilitation including a probably outpatient aftercare. The aim of orthopedic inpatient rehabilitation (phase II) is to restore the health status based on the bio-psycho-social health model.

1.1.1. Situation in Austria

Musculoskeletal diseases, caused by inflammatory, degenerative processes or injuries, permit an inpatient orthopedic rehabilitation (WHO, Phase II [21, 22]) over 3–4 weeks for restoring physiological functioning and reintegrating to social and professional life.

Based on historical decisions [23] and Health Technology Assessments (HTA) (e.g., [24]), there is currently a framework of contracts with the federal Austrian social security institutions

entities in place². This includes performance agreements for orthopedic rehabilitation (see [25]), based on criteria regarding the quality of processes and treatment outcomes [21]. Criteria include individual detailed results that demand a standardized statistical recording of outcome parameters from admission up to discharge of the rehabilitation program. Furthermore, evaluation and statistical analyses of these medical outcomes are generally not open to the public [26].

1.1.2. Implementation of orthopedic rehabilitation in Austria

There is strong evidence that rehabilitation is necessary as part of the treatments for inflammatory or degenerative diseases, as well as for postoperative conditions or injuries of the musculoskeletal system. The underlying condition’s severity and expectancy of the restoration of physical function are requirements for obtaining an inpatient orthopedic rehabilitation. For patients affected by musculoskeletal disease, medical treatment and a large range of rehabilitative treatments are available. The inpatient treatment lasts on average 2–3 hours per day. An individual rehabilitative program consisting of active and passive treatments is provided (see **Table 1**). Active treatments consist of physical activity including gymnastic and individual physiotherapy sessions and the medical training focuses on underwater , ergometer , Nordic walking , strength , balance , relaxation and motion training. Passive treatments contain sessions like massages, thermotherapy, electrotherapy, ultrasound and educational lessons like various lectures, or psychological coaching. Each patient is offered a program of at least 1800 therapy minutes during 3 weeks, split up into approximately 50% active and 50% passive treatments that highly surpass the physical activity guidelines of the WHO (150 minutes workout in moderate intensity and strengthening exercise twice a week).

	Physical exercise	Medical training	
Active	Gymnastic	Underwater gym	Approx. 50%
	Individual physiotherapy	Ergometer training	
	Sensomotoric training	Strength training	
	...	Balance & function training	
	(Passive) Treatments	Education	
Passive	Massages	Health-related talks and trainings	Approx. 50%
	Thermotherapy	Psychological	
	Electrotherapy	Coaching	
	Ultrasound	...	
Required total amount		At least 1800 minutes (within 3 weeks)	

Table 1. Quantity and type of therapies over three weeks.

²In particular the pension insurance institution.

Medical rehabilitation is structured in different ways all over the world, although a tendency for a standardization of the social and health system can be observed. In Germany and Austria, the social insurance offers inpatient orthopedic rehabilitation over a period of 3–4 weeks in specialized rehabilitation centers with an interdisciplinary team. Some other countries only provide outpatient rehabilitation [27].

1.2. Efficacy and sustainability of orthopedic rehabilitation

Diseases demand a certain continuity of the therapeutic process for success after rehabilitation. This means that rehabilitative programs should focus not only on physical activity programs during the stay but also on sustainability of physical activity after the rehabilitation. Therefore, an inpatient stay should also lead to a health-related modification in lifestyle. The efficacy of inpatient rehabilitative programs and especially their sustainability over a long period are important research issues. Literature shows that during the rehabilitative stay, pain can be significantly reduced, and a long-term improvement of physiological functionality can be achieved. The success can be measured even after 12–21 months after rehabilitation [28, 29].

The fact remains that physical activity programs have a positive impact on the physiological performance of patients. However, the dropout rate for long-life active and health-related lifestyle change maintenance is high. Findings support the sustained efficacy of an intense, multimodal orthopedic rehabilitation, with moderate evidence, including an improved subjective health status and reduced pain [30]. For rehabilitation treatment after hip and knee endoprosthesis (TEP) [31–34] and chronic back pain [35–37], a level of evidence Ia/Ib is stated. The combination of physiological and psychological training significantly leads to positive changes [18, 38, 39]. The data confirm that a combination of physical activity and psychosocial training-based treatments has an influence on pain reduction and mental well-being.

Studies in other countries state that about 57% of patients in Europe and even 70% of patients in the US are able to restart regular full-time work and show significant improvements of psychosocial, physiological parameters after inpatient rehabilitation [40–43]. An interdisciplinary treatment of medical, physical activity based and psychological therapy ensures a high return to professional life [44, 45].

2. Methods

The medical outcome parameters required by the performance profile of the federal Austrian social security institutions involved in quantifying the quality of rehabilitation outcomes are the basis of this work. We provide descriptive standardized numeric indicators of the rehabilitation process as well as monocentric reference data for a 3-week inpatient orthopedic rehabilitation program. Data collection was performed by doctors and healthcare professionals during routine medical treatment. Standardized clinical characteristics of patients were recorded systematically at the time of admission and discharge. The easily quantifiable medical parameters included general health characteristics such as body measurements and

cardiovascular parameters, psychological indicators such as pain and subjective health, as well as specific indicators such as daily activities, motor function and physical performance (see **Table 2**).

These quality-of-outcome measures are to be documented in the discharge report at the beginning and the end of the phase II rehabilitation (this correlates with the methodology of a pre-post comparison). Respectively, data were also summarized using a descriptive evaluation in terms of content and factor analysis. This provides us a simple descriptive evaluation model through independent factors for the sake of a complete evaluation of the outcome quality [26].

2.1. Orthopedic reference sample at the clinical trial center

During the service period from 2016 to 2018, a total of 10,373 patients (61.00 ± 13.65 years, 51.7% women) were enrolled in a specialized interdisciplinary hospital for rehabilitation (Humanomed Center, Austria) (**Table 3**). A categorization of reasons for hospital treatment was based on the admission diagnosis. Reasons for admission were musculoskeletal diseases (M, 85%) or injuries (S, 15%). Categorizations were based on ICD-10. The majority of patients were admitted for rehabilitation due to back pain (29.6%) followed by upper/lower limb joint as well as knee (21.4%), hip (16.3%) and shoulder (12.0%) disorders. About 73.3% of the patients were admitted after surgery (OP)³. Just under a half of those patients (42.2%) were treated with an endoprosthesis (EP) (overall, 31.9%). The proportion of EP rehabilitation procedures was 64.7% for knee patients and 84.7% for hip patients. The period between acute care rehabilitation (OP) averaged 8.4 ± 4.0 weeks. However, patients with knee and hip TEP progressed from phase I to phase II earlier (median, 6 weeks)⁴.

The average inpatient length of stay was 22.00 ± 2.6 days; 2.2% of all patients discontinued their inpatient treatment prematurely due to a loss of rehabilitation capacity (for example, acute illness) or for private reasons (criterion ≤ 18 treatment days). In 3.8% of the patients, the inpatient stay was 4 weeks.

2.2. Ethical aspects

This study (A retrospective study-Routine Outcome Parameters of an Inpatient Rehabilitation in Austria) was reviewed and approved by an Ethics Committee (Vote by the Ethics Committee of the Medical University of Graz, dated 02.05.2019, EC Protocol Number: 31-321 ex 18/19). Person-related and health-related data were collected as part of routine medical care and quality management at the Humanomed Center Althofen (9330 Althofen, Moorweg 30). Data processing was done according to standard operating procedure by the responsible data processing party: Humanomed Center Althofen GmbH, Data Protection Officer: Mag. Karl Klein, Jesserniggstraße

³Corresponds to a follow-up treatment procedure (AHV), which can be used in Austria for three to four months from the grant date (in Germany within 14 days after discharge Phase I). The remaining patients are a (R) HV [(rehabilitation) treatment], where the time limit is 8 to 12 months.

⁴For knee and hip TEP patients in orthopedic rehabilitation, a quasi-experimental control group (waiting group) results from the different onset times [period between acute care (surgery time) and the beginning of the follow-up treatment procedure (AHV)].

Orthopedic rehabilitation indicators for medical quality outcomes (MQO, [z*])						
Unspecific general health parameters			Disease-specific health parameters (indication-specific outcomes)			
MED1	BMI	[kg/m ²]	ORT1	Quality of life	EQ-5D	[%]
	Abdominal circumference	[cm]				
	ANATOMY	[z]		ADL (activities of daily living)		[z]
MED2	Blood pressure systolic	[mmHG]	ORT2	Motoric function	Roland-Morris	[]
	Blood pressure diastolic				WOMAC	[]
	Resting heart rate	[bpm]			Constant-Murley	[]
	PHYSIOLOGY	[z]		FUNCTION		[z]
MED3	VAS (pain)	[cm; 0–10]	ORT3	Walk test	Timed up & go	[sec]
	EQ VAS (self-rated health)	[%; 0–100]			10 m	[sec]
	DISCOMFORT	[z]		PHYSICAL ABILITY		[z]
UH _i	Unspecific health index MED1, MED2 & MED3	[z]	SO _i	Specific Ortho Index ORT1, ORT2 & ORT3		[z]
MQO	(overall) Medical quality outcome UH _i & SO _i					[z]

*Standard scores, also called z-values (z), are calculated by subtracting the (population) mean from an individual raw score and then dividing the difference by the (population) standard deviation (here: for all orthopedic patients). As shown in the results section, deviations from zero respectively mean differences of z-values can be interpreted as an effect size (c.f. Cohen's d).

Table 2. Parameters of medical quality outcomes.

Classification according to ICD-10	Number of patients		Age	Women		Endoprosthesis	
Localization/main diagnosis	abs.	%	Mean \pm SD	abs.	%	abs.	%
Back (spine) M41, M43, M48, M50, M51, M53, M54, S32, S22, S12	3067	29.6	57.2 \pm 13.3	1509	49.2	12	0.4
Knee M17, M23, S83	2220	21.4	64.7 \pm 12.5	1225	55.2	1437	64.7
Hip M16	1688	16.3	67.1 \pm 11.0	928	55.0	1429	84.7
Shoulder M75, S42, S43, S46	1249	12.0	57.8 \pm 11.3	562	45.0	32	2.6
Lower leg and thigh S82, S86, S72	723	7.0	62.1 \pm 16.5	414	57.3	103	14.2
Other arthritis M19, M25	400	3.9	62.7 \pm 13.4	219	54.8	139	34.8
Other T84, S52, M79, M77, M87, S92, M06	330	3.2	60.7 \pm 14.4	173	52.4	141	42.7
Other diseases (musculoskeletal system) ICD-10Kat < n = 20	696	6.7	55.3 \pm 15.4	338	48.6	17	2.4
Total	10373	100.0	61.0 \pm 13.6	5368	51.7	3310	31.9

Table 3. Sample number of patients undergoing rehabilitation of the musculoskeletal system.

9, 9020 Klagenfurt. The data from the hospital information system upon which the publication is based were compiled in compliance with all regulations of the Austrian Privacy Act and the Declaration of Helsinki in its current version. Data collection was done also in accordance with national legalization (hospital statutes, contracts with insurance-authorized institutions, etc.) through the rational of mainly collecting scientific data in the public interest.

2.3. Medical outcome quality

Medical outcome quality is defined as the “measurable change in the professionally assessed state of health, the quality of life and the satisfaction of a patient” (see Austrian Federal Quality of Healthcare Act, GQG). The outcomes become visible by “the difference between the initial state and the state at treatment end” (c.f. [46]).

The outcome measurement in rehabilitation can be based on various methodological approaches, such as questionnaires, performance tests, equipment measurements and functional physical examinations. The outcome quality measurement, “the outcome,” includes features on health (e.g., symptoms and pain), functional levels (e.g., performance) and educational levels. In addition to the patient’s subjective assessment (“patient-reported outcomes (PRO)”), medical, diagnostic and other relevant outcome measures/criteria (e.g., ICF) are documented by healthcare professionals.

The aim of the present work is to provide a valid basis for routinely assessing the quality of medical outcomes (routine outcome measurement) based on common data acquisition. The focus therefore is on general (nonspecific, body constitution based) and indication-specific parameters. Continuously collected medical reference values have diverse potential benefits in quality assurance, awareness raising, goal setting and decision-making. The data are also important for evaluation of different care models.

2.3.1. Quantifying “medical outcome quality”

In addition to the descriptive analysis of single indicators, the analysis evaluates the effects of inpatient rehabilitation stay and the medical quality outcome (MQO). This is calculated on the basis of representative monocentric normative data ($N = 10,373$; see **Table 3**). The selection of clinical parameters follows the requirements of federal social security institute in the performance profiles of accredited Austrian institutions for outcome analysis, which should guarantee a comparable medical service quality standard. A success index is calculated by summarizing the compulsory basic clinical data of the patients (see **Table 2** and [26]).

1. The “Unspecific Health Index” is the arithmetic mean of three independent areas of measurement: body measurements (BMI and abdominal circumference), cardiovascular parameters (blood pressure and resting heart rate), discomfort (visual analogue scales (VAS pain, [47]) and subjective health status (EQ-VAS, [48])). These parameters should provide a simple and quick overview of “unspecific” effectiveness of a rehabilitative stay.
2. The “Specific Ortho Index” corresponds to a z-normalized mean of “activities of daily living” (EQ5D), “function” (Roland-Morris, WOMAC or Constant-Murley, depending on the affected body region) and the “physical ability” (walking tests).

The Unspecific Health Index can be interpreted as an indicator of general health status or the current body constitution, whereas the Specific Ortho Index corresponds to a disease-specific health parameter (indication-specific outcome). Both indexes together form the “medical quality outcome” in equal parts.

2.3.2. Statistical methods

Based on the value distributions, the individual outcome parameters were transformed into z-values, which allowed a conversion into percentiles. By means of the z-standardization, different scaled quantities can be summarized and changes can be uniformly quantified [standardized mean differences (SMD)]. A value of 50% (median) or a z-value of zero corresponds—given a normal distribution—to the representative mean of admission and discharge data of all patients at the clinical trial center. A z-value of 1, corresponds to a deviation from the mean by one standard deviation. Z-differences with no significant changes are in a range of 0.00 ± 0.20 . Changes from admission to discharge are illustrated by effect sizes. In addition, the number of patients (relative frequency in %) is stated, which could improve clinically (categorical representation: better, equal, and worse). The threshold used is an average z-difference (\sim SMD) >0.20 (MED 1–3, ORT 1–3) or >0.33 (unspecific Health Index, Specific Ortho Index, and overall medical quality outcome). Alternatively, the average (percentile) change compared to the time of admission is calculated and, if necessary, treated according to the indication.

Statistical data processing was performed using IBM® SPSS® Statistics (version 22). In addition to descriptive methods, statistical analysis included parametric methods such as multifactorial variance analyses for repeated measures [(M)AN(C)OVA; between-effects: gender (2), covariate: age, within-effect: rehabilitation course (2)], regression analysis and Pearson correlations. Individual missing values were not replaced for statistical analysis. The specification of p-values was omitted, instead effect sizes were used [partial η^2 and standardized mean differences (Cohen's d or z-values/-differences, SMD)]. The representation of the partial η^2 (η^2) was chosen because even the very small numerical differences became statistically significant even if they were not relevant in terms of content and clinical relevance. A η^2 between 0.01 and 0.06 corresponds to a small effect. Occurrences of 0.06–0.14 correspond to a middle effect and values >0.14 to a large effect [49]. The application of multivariate variance analyses (MANOVA) and a factor-analytical reduction of the basic clinical data to individual factors or a total value (MQO) follow substantive, statistical considerations for better clarity.

3. Results

The effect of the rehabilitation stay and the change between the initial state and the discharge state differ between the individual success factors for medical rehabilitation (see **Tables 4, 6** and **7**). Specific and unspecific outcomes show a comparable change in sensitivity ($\eta^2_{\text{unspecific}} = 0.522$ [UH_i] vs. $\eta^2_{\text{specific}} = 0.540$ [SO_i]). The relationship between specific and unspecific

outcome characteristics (changes) is small ($r < 0.20$, see **Figure 1** and **Table 5**), which is reflected in a multivariate analysis of temporal changes in the variance ($\eta^2_{\text{unifactorial}} = 0.654$ [MQO_i]).

The nonspecific overall score-the “Health Index (UH_{Index})”-shows that 72.5% of patients benefit directly from the rehabilitation stay. About 21.8% of the patients remain unchanged and 5.8% worsen between the beginning and the end of the rehabilitation (see **Table 4**). The detailed analysis of average improvement in general health features by 13.58 percentile points shows that anatomical features, such as body mass index and abdominal circumference, remain unchanged over the 3 weeks in the majority (86.4%). By contrast, cardiovascular features such as blood pressure and resting heart rate are directly influenced by inpatient rehabilitation, with an average improvement of 11.5 percentile points. The most pronounced effects of inpatient rehabilitation can be seen in the symptoms of complaints, where almost every rehabilitation (84.9%) reported a significant improvement. A similarly positive change can be seen in the ADL score (+17.6 percentile points), motor function (+22.2 percentile points) and physical performance, where 2/3 (67.5%) of patients can improve markedly.

[%]	better	equal	worse	Ø-improvement*
MED1: Anatomy (BMI, AC)	11,2	86,4	2,4	<i>MED1: +1,33</i>
MED2: Physiology (BP, RHR)	56,5	15,7	27,8	<i>MED2: +11,50</i>
MED3: Discomfort (VAS, SHS)	84,9	9,9	5,2	<i>MED3: +27,89</i>
<i>BMI... Body Mass Index, AC ... Abdominal Circumference, BP... Blood Pressure, RHR... Resting Heart Rate, VAS... Visual Analog Skale (pain), SHS... Subjective Health Status (EQ-VAS); Threshold for classification: MED1-3: 0,20 (z-difference);</i>				
Achievements of an multidisciplinary inpatient musculoskeletal system rehabilitation				
[relative frequency in %]	better	equal	worse	Ø-improvement*
Unspecific Health Index	72,5	21,8	5,8	<i>UH_{Index}: +13,58</i>
Specific Ortho Index	77,0	19,0	4,0	<i>SO_{Index}: +17,70</i>
Overall Medical Quality Outcome	81,3	16,4	2,3	<i>MQO_{Index}: +15,62</i>
<i>*. Average improvement (percentiles) from admission to discharge; Threshold for classification Unspecific Health, Specific Ortho & overall Medical Quality Outcome Indices ~0,33 SMD;</i>				
[%]	better	equal	worse	Ø-improvement*
ORT1: ADL (EQ5D)	58,6	33,1	8,3	<i>ORT1: +17,57</i>
ORT2: Function (RM, WOMAC or CM)	76,3	18,0	5,6	<i>ORT2: +22,17</i>
ORT3: Physical Ability (WT)	67,5	30,7	1,8	<i>ORT3: +12,96</i>
<i>ADL... Activities of Daily Living, RM... Roland Morris, CM... Constant Murley, WT... Walking Tests; Threshold for classification: ORT1-3: 0,20 (z-difference);</i>				

Table 4. Overview of medical quality outcomes.

Almost all considered medical factors (MED, ORT) provide a comparable contribution to the overall success (MQO, all $r \geq 0.40$, except for MED1: $r = 0.11$). The correlation between Unspecific Health Index and Specific Ortho Index is relatively low ($r = 0.19$; see **Figure 1** and **Table 5**). Therefore, immediate changes in unspecific health scores are not directly associated with improvements in (indication-) specific functional characteristics. One exception is the (subjective) complaints (MED 3), which are related to specific outcome changes ($r = .34$).

However, the extent of improvement in medical outcome and the effect size are similar in all areas (see **Tables 4, 6** and **7** and **Figure 1**). Just the anatomy factor (MED 1) changed only slightly during rehabilitation ($\eta^2_{\text{MED1}} = 0.072$; **Tables 6** and **7**). The individual parameters for all patients are presented in **Tables 6** and **7** below.

3.1. Output values and descriptive data for individual measurements

The starting point (initial) values of rehabilitation clearly show the deficits of the affected patients (see **Tables 6** and **7**). The average BMI is 28.9 ± 5.4 units (37.0% of patients have a BMI > 30) and 77.3% of patients have “high-normal” or “hypertonic” blood pressure. The perceived pain (VAS; 0–10) of patients is 3.8 ± 2.1 and the subjective health status (EQ-VAS; 0–100) is estimated to be $63.7 \pm 16.6\%$ on average.

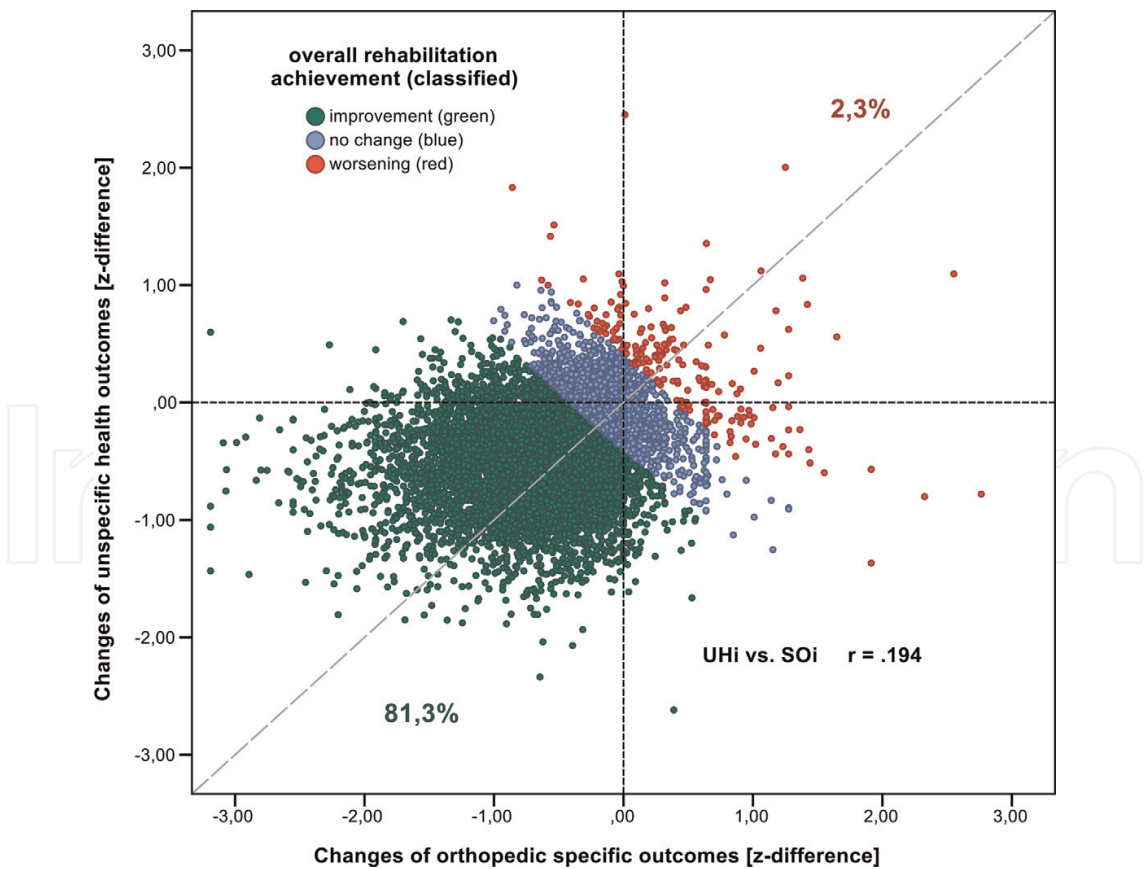


Figure 1. A value of zero (± 0.20 [z]) stands for no significant changes from admission to discharge (blue dots). The mean for UHi is -0.45 ± 0.43 and for SOi -0.59 ± 0.55 . The overall MQOi (mean of UHi & SOi) is -0.52 ± 0.38 (centroid).

Correlation of changes in medical factors [Pearson]		MED 1 (Anatomy)	MED 2 (Physiology)	MED 3 (Discomfort)	UH _i (Unspecific health ind.)	Overall MQO (medical quality outcome)
ORT 1 (ADL)	r	0.000	−0.007	0.285	0.162	0.671
	p	0.982	0.496	0.000	0.000	0.000
ORT 2 (Function)	r	0.012	−0.006	0.314	0.183	0.638
	p	0.288	0.620	0.000	0.000	0.000
ORT 3 (Physical ability)	r	−0.020	−0.011	0.072	0.033	0.399
	p	0.113	0.406	0.000	0.010	0.000
SO _i (Specific Ortho Index)	r	−0.002	−0.009	0.340	0.194	0.833
	p	0.878	0.385	0.000	0.000	0.000
Overall MQO (medical quality outcome)	r	0.107	0.444	0.579	0.704	1
	p	0.000	0.000	0.000	0.000	

Bold values show the correlation of each health parameter with the overall medical quality outcome.

Table 5. Correlations between changes in MQO factors.

MQO indicators & factors	Initial values (beginning of rehabilitation; prae)		Change from admission (prae) to discharge (post)				
Measure	Mean ± standard deviation (SD)		Mean diff. (post-prae) ±SD		(z) Normalized difference ± SD		part. Eta ²
BMI [kg/m ²]	28.89	5.38	−0.15	1.45	−0.03	0.27	0.011
Abdominal circumference [cm]	100.24	13.71	−0.99	2.78	−0.07	0.20	0.114
MED 1: Anatomy [z]	0.10	0.97	−0.05	0.18	−0.05	0.18	0.072
RRsys [mmHG] (blood pressure systolic)	130.74	11.30	−4.78	13.00	−0.37	1.02	0.119
RRdia [mmHG] (blood pressure diastolic)	76.87	7.45	−2.28	9.44	−0.29	1.19	0.055
heart rate [bpm]	78.74	11.67	−1.41	12.13	−0.12	1.01	0.014
MED 2: Physiology [z]	0.14	0.89	−0.37	1.01	−0.37	1.01	0.120
VAS [cm; 0–10] (pain)	3.75	2.14	−1.68	1.69	−0.70	0.70	0.501
self-rated health [%; 0–100] (EQ-VAS)	63.70	16.60	13.79	14.84	−0.80	0.86	0.465
MED 3: Discomfort [z]	0.45	0.92	−0.91	0.75	−0.91	0.75	0.598
UH: unspecific health Index [z] MED1, MED2, MED3	0.23	0.59	−0.45	0.43	−0.45	0.43	0.522
Bold values show summarized factors of outcome measures from unspecific general health parameters (see Table 2).							

Table 6. Starting point values and changes in individually measures quantities.

MQO indicators & factors	Initial values (beginning of rehabilitation; prae)		Change from admission (prae) to discharge (post)				
	Mean \pm standard deviation (SD)		Mean diff. (post - prae) \pm SD		(z) Normalized difference \pm SD		part. Eta ²
ORT 1: ADL [0-100 & z] (activities of daily living; EQ5D)	68.36	24.36	9.22	13.20	-0.59	0.84	0.361
Roland-Morris [0-24]	8.42	5.26	-3.16	3.92	-0.59	0.73	0.394
WOMAC [Sum; 0-240]	73.70	42.17	-32.54	32.26	-0.77	0.77	0.504
Constant-Murley [Sum; 0-100]	41.09	17.19	17.98	11.53	-0.91	0.58	0.709
ORT 2: Function [z]	0.36	0.97	-0.73	0.73	-0.73	0.73	0.475
Time up & go [sec]	11.04	6.49	-2.62	3.30	-0.46	0.58	0.393
10m [sec]	9.55	5.23	-1.95	2.88	-0.43	0.63	0.327
ORT 3: Physical ability [z]	0.22	1.11	-0.44	0.55	-0.44	0.55	0.403
SO: specific ortho index [z] ORT1, ORT2 & ORT3	0.31	0.83	-0.59	0.55	-0.59	0.55	0.583
Bold values show summarized factors of outcome measures from disease-specific health parameters (see Table 2).							

Table 7. Initial values and changes in individual measurements.

Unspecific and indication-specific outcome data (see **Tables 6** and **7**) show clear success during the rehabilitation stay, with complaints (MED 3, $\eta^2 = 0.598$) and motor function (ORT 2, $\eta^2 = 0.478$) improving markedly within the 3 weeks.

Based on the subsample survey of knee and hip TEP patients, it can be seen that changes occur in the nonspecific factors independent of the time of rehabilitation (interaction: time x post-op week: $\eta^2 = 0.001$). This result is in contrast to (disease-specific) outcome characteristics (SOi) where the time of onset (post-op week) plays a more important role (interaction: $\eta^2 = 0.061$; see **Table 9** (cf. [26])).

3.2. Comparison of outcomes based on ICD-classification

If one considers the initial medical evaluation values and changes thereof as a result of the inpatient rehabilitation stay, we need to evaluate also the initial severity and admission diagnosis. The admission diagnosis was evaluated based on the standardized ICD-10 classification ("ICD") (see **Tables 8** and **9**). This classification shows that knee patients have worse MED 1 (Anatomy) values at the beginning of rehabilitation (0.36 ± 0.96). In back pain patients, especially negative MED 3 initial medical evaluation values (Discomfort) are prominent (MED 3: $\eta^2 = 0.068$). The symptom-specific characteristics (ORT, SOi) and their differences in initial values were somewhat less pronounced (SOi: $\eta^2 = 0.010$ vs. UHi: $\eta^2 = 0.017$; see **Table 9**).

Overall adding up the MQO factors, the initial medical evaluation values are comparable between the ICD diagnostic groups ($\eta^2_{\text{MQOi}} = 0.004$), but in individual cases, they certainly play an important role ($\eta^2_{\text{multivariat}} = 0.080$, see **Table 9**).

3.3. Influencing factors of age, gender and initial values

Depending on further grouping characteristics (between factors), it is shown that gender ($\eta^2_{\text{multivariat}} = 0.076$) and age ($\eta^2_{\text{multivariat}} = 0.067$) contribute a significant amount to initial values, which is lower within unspecific than in specific parameters (see **Table 9**; (cf. [26])). Additionally, medical initial values are influenced by the factor injuries (S) vs. chronic conditions (M; $\eta^2_{\text{multivariat}} = 0.058$), as well as the symptom presentation "ICD" ($\eta^2_{\text{multivariat}} = 0.080$).

Potential success through rehabilitation with unspecific outcome indicators (changes of condition pre and post, see also **Table 4**) can be observed within all grouping characteristics of a similar magnitude (interaction time x between factor: $\eta^2_{\text{UHi}} < 0.003$ see **Table 9**). In contrast, age, ICD, postOP and initial value of MQO play a role for alterations in specific outcome indicators (Age: $\eta^2_{\text{OHi}} = 0.039$, ICD: $\eta^2_{\text{OHi}} = 0.040$, postOP: $\eta^2_{\text{OHi}} = 0.061$ and initial MQO value: $\eta^2_{\text{OHi}} = 0.143$). All these factors influence the specific outcome significantly. Older patients (>61 years of age), patients with knee and hip issues, patients who enter phase 2 earlier after surgery (<6 weeks) and particularly patients with worse medical initial values show a more advantageous rehabilitation outcome for symptom-specific indicators (not shown).

MQO indicators & factors		Initial values (beginning of rehabilitation; prae)		Change from admission (prae) to discharge (post)		
Classification according to ICD-10 (cf. Table 3)		Mean* \pm standard deviation (SD)		Mean diff.** (post - prae) \pm SD		part. Eta ²
MED 1: anatomy	hip	0.15	0.94	-0.05	0.17	0.069
	knee	0.36	0.96	-0.06	0.18	0.086
	back (spine)	0.06	0.97	-0.05	0.19	0.058
	total	0.18	0.97	-0.05	0.18	0.068
MED 2: physiology	hip	0.19	0.90	-0.38	1.02	0.120
	knee	0.18	0.84	-0.34	1.00	0.107
	back (spine)	0.13	0.93	-0.40	1.03	0.129
	total	0.16	0.89	-0.37	1.01	0.116
MED 3: discomfort	hip	0.07	0.90	-0.83	0.68	0.600
	knee	0.38	0.86	-0.91	0.73	0.610
	back (spine)	0.65	0.92	-0.99	0.79	0.610
	total	0.43	0.93	-0.92	0.74	0.596
UHi: unspecific health Idx	hip	0.14	0.57	-0.42	0.40	0.517
	knee	0.31	0.57	-0.44	0.42	0.516
	back (spine)	0.28	0.61	-0.48	0.44	0.538
	total	0.26	0.59	-0.45	0.43	0.515
ORT 1: ADL	hip	0.37	1.09	-0.84	0.95	0.437
	knee	0.34	0.96	-0.69	0.86	0.390
	back (spine)	0.23	0.97	-0.52	0.80	0.295
	total	0.30	1.00	-0.66	0.87	0.378
ORT 2: function	hip	0.25	0.99	-0.78	0.77	0.507
	knee	0.37	0.96	-0.78	0.76	0.507
	back (spine)	0.27	0.97	-0.61	0.73	0.411
	total	0.30	0.97	-0.71	0.76	0.473

MQO indicators & factors		Initial values (beginning of rehabilitation; prae)		Change from admission (prae) to discharge (post)		
Classification according to ICD-10 (cf. Table 3)		Mean* \pm standard deviation (SD)		Mean diff.** (post - prae) \pm SD		part. Eta ²
ORT 3: physical ability	hip	0.37	0.93	-0.53	0.53	0.505
	knee	0.24	0.84	-0.47	0.47	0.498
	back (spine)	-0.07	0.98	-0.31	0.43	0.339
	total	0.15	0.94	-0.42	0.48	0.456
SOi: specific ortho Idx	hip	0.32	0.81	-0.72	0.55	0.633
	knee	0.32	0.73	-0.64	0.49	0.630
	back (spine)	0.16	0.78	-0.48	0.46	0.513
	total	0.26	0.77	-0.60	0.51	0.597
MQOi: overall idx	hip	0.23	0.56	-0.57	0.37	0.703
	knee	0.31	0.54	-0.54	0.36	0.697
	back (spine)	0.22	0.58	-0.48	0.36	0.641
	total	0.25	0.56	-0.52	0.36	0.677

*Positive (z-) values show a bad initial state at the beginning of rehabilitation.

**Negative (z-normalized) differences show an improvement from admission to discharge.

Bold values show overall means of summarized medical quality factors for the three most common orthopedic diagnoses.

Table 8. Symptom-specific (ICD) MQO.

Factors (main effects)	Unifactorial part. Eta ² for initial values (prae)*					Unifactorial part. Eta ² for changes (prae-post; interaction)**					
	Sex	Age	Type	ICD***	Post-OP	Sex	Age	Type	ICD	Post-OP	Initial value _{MQO}
MQO variables	f/m	4-stage	M/S	h/k/b	5-stage	f/m	4-stage	M/S	h/k/b	5-stage	3-stage
MED 1: anatomy	0.018	0.023	0.024	0.013	0.001	0.004	0.005	0.000	0.001	0.001	0.006
MED 2: physiology	0.018	0.003	0.001	0.000	0.003	0.002	0.001	0.000	0.000	0.001	0.023
MED 3: discomfort	0.013	0.007	0.001	0.068	0.016	0.005	0.002	0.000	0.007	0.002	0.042
Unspecif. health_{idx}	0.007	0.011	0.007	0.017	0.007	0.000	0.001	0.001	0.003	0.001	0.061
ORT 1: ADL	0.028	0.041	0.011	0.003	0.012	0.006	0.021	0.000	0.022	0.033	0.055
ORT 2: function	0.012	0.029	0.003	0.002	0.005	0.005	0.009	0.000	0.012	0.021	0.085
ORT 3: physical ability	0.032	0.161	0.027	0.042	0.020	0.009	0.041	0.005	0.040	0.048	0.094
Specific ortho_{idx}	0.036	0.103	0.018	0.010	0.015	0.013	0.039	0.001	0.040	0.061	0.143
MQO_i: overall_{idx}	0.009	0.061	0.003	0.004	0.004	0.006	0.021	0.000	0.011	0.033	0.168
Multivariate (Pillai's trace)	0.076	0.067	0.058	0.080	0.016	0.022	0.020	0.006	0.040	0.020	0.103

Between factor: sex (female, male), age (quantile; ≤ 52, 53–61, 62–72, 73+), type (disease [M], injury [S]), ICD (hip, knee, back/spine), post-OP (period between surgery and rehabilitation; ≤ 6 weeks, 43–70 days, 71–105 days, 106–366 days, >1 year), initial value MQO (tertile); A part. Eta² (η^2) between 0.01–0.06 corresponds to a small effect, occurrences of 0.06–0.14 a middle effect and values >0.14 a large effect.

*Initial state at the beginning of rehabilitation.

**Differences (improvements) from admission to discharge (corresponds to the interaction: time x factor).

***C.f. Table 8.

Bold values show the influence (effect size) of the approval diagnosis on baseline values and the impact of other moderating variables on summarized unspecific and specific health factors.

Table 9. MQO and potential influence factors.

4. Discussion

In times of dwindling resources, evidence-based justifications of medical measure effectiveness are gaining ever more practical and healthcare economic importance. New possibilities of medical treatment measures and constantly changing framework conditions are a challenge for quality assurance management, which uses structural, process and outcome characteristics to evaluate the degree to which predefined goals have been achieved. Potential environmental influences or a change of framework conditions can also be evaluated with regard to the MQO. The recorded routine data are used both as an evaluation criterion and as comparison data of the expected MQO or output values.

Current treatment paths emphasize a stratified approach, active therapies and educational measures, whereby evidence of effectiveness and clinical practice still clearly diverge [28, 50, 51].

Based on presented clinical observations through routine operating procedures of a multidisciplinary inpatient musculoskeletal system rehabilitation, evaluation can be performed. The evaluation takes into account facility and patient comparisons and is based on standardized assessments of different treatment options as well as factors of outcome quality. Existing performance profiles have a certain amount of latitude to focus on treatment or to apply promising therapeutic options. Such differentiated treatment pathways are necessary for efficient and successful treatment so that individual patients or specific patient groups can be addressed.

A physician/therapist or facility can use the results presented to make an evidence-based decision relatively quickly on whether the treatment process is proceeding to their satisfaction. Orthopedic patients receive a realistic assessment of what and how much they will improve their physical abilities through the 3-week inpatient medical treatment.

The selection of outcome parameters follows evidence-based and economic considerations that should guarantee a comparable standard of quality medical treatment. Indication-specific characteristics (ORT, SO_i) are at the center of the rehabilitative treatment, to restore the ability to function and work or to reintegrate into the social and professional environment. Another focus is on nonspecific health features such as individuals that are overweight, have high blood pressure or are physically inactive. These characteristics are associated with poorer health, cardiovascular disease and metabolic disorders. They are among the most important variable risk factors for chronic diseases and premature death [52].

An important task in inpatient rehabilitation is, in addition to the individual symptomatic treatment of a patient, to sustainably reduce these risk factors. Quality of life and functioning are characterized by positive lifestyle modifications, for example, an increase in physical activity. A reduction in the recorded basic clinical parameters such as BMI, abdominal circumference, blood pressure, heart rate and pain [53–56] is therefore also highly relevant in the inpatient rehabilitation of degenerative and inflammatory disorders of the musculoskeletal system [57, 58]. A mathematical comparison with “healthy” patient reference data underlines the importance of the MQO factors presented in this work, which deviate in the order of about one standard deviation of healthy individuals.

In order to work meaningfully and deductively, it is helpful to reduce the abundance of partially redundant information to a manageable, uniform level. An additive summary of independent medical areas (factors) to a key figure (UH_i or SO_i and overall MQO) is to be discussed in terms of content and statistics. These key figures give a simple and quick overview of the “unspecific” effectiveness of the rehabilitative stay for certain healthcare teams or treatment programs.

4.1. Nonspecific quality of outcomes

When assessing the effectiveness of inpatient rehabilitation based on the nonspecific health outcome characteristics, it is not so important to use grouping characteristics such as symptoms. Grouping based on gender and age is here too of minor importance. Comparing the values at discharge with the initial medical evaluation data shows that 72.5% of patients benefit directly from inpatient rehabilitation (see **Table 4**). Significant interactions with grouping features are present but can be classified as “small” compared to the main effects ($\eta^2 < 0.003$; see **Table 9**). The observed strong rehabilitation effect is similar for all subgroups ($\eta^2 > 0.500$; see **Tables 6 and 8**). This unspecific success is probably attributable to all inpatient rehabilitation stays and to the preventive effect of activity or movement in the rehabilitation setting.

The change in the nonspecific MQO is independent of the time of rehabilitation, the post-OP week ($\eta^2_{UH_i} < 0.001$; see **Table 9**). In an untreated “real” control group without rehabilitation, therefore, no positive change in the constitutional state of health is to be expected.

In contrast, the importance of early inpatient rehabilitation as early as possible is revealed in disease-specific outcome characteristics such as function or physical ability ($\eta^2_{OH_i} = 0.061$). This underlines the importance of a multidimensional view of specific and nonspecific outcome quality, describing two independent (active) components of rehabilitation (see **Figure 1** and **Table 5**).

4.2. Specific quality of outcomes

The most pronounced effects of inpatient rehabilitation are seen in the complaint (MED 3) and indication-specific characteristics (ORT 2, ORT 3 and SO_i). More than 2/3 of patients experience significant improvement of symptoms and specific characteristics (see **Table 4**). About 77.0% of patients show indication-specific improvement of outcomes in inpatient rehabilitation. However, 19.0% did not show significant changes and 4.0% showed worsening from rehabilitation beginning to rehabilitation end. Therefore, it is important to remember that not all patients can directly benefit from treatment. In sum, (overall MQO) improvement is achieved, in the vast majority (81.3%, $SMD = 0.52 \pm 0.38$; see **Figure 1**). Improvement of unspecific and indication-specific outcome parameters is achieved in a comparable magnitude.

Unlike nonspecific health scores, moderating factors play a more important role in the specific outcome quality. In particular, patients who enter Phase II earlier (<6 weeks) after surgery and patients with worse initial medical evaluation show better rehabilitation success in symptom-specific characteristics (see **Table 9**).

4.3. The applicability of our results in rehabilitative clinical practice

Despite large international differences in healthcare teams and treatment measures in rehabilitation, the observed effect sizes can support individual evaluation but cannot replace it. In addition to case by case evaluation, it is important to consider the medical focus, the rehabilitative practice and performance profiles, as documented outcomes come about through different treatment programs and the associated different use of healthcare resources.

Absolute values and individual profiles of the MQO should always be evaluated according to the given setting and at the doctor's discretion. Single measurements are subject to a variety of moderating influences and measurement errors. The presented continuous measures of MQO have advantages in terms of their (scale) properties and sensitivity to frequently applied categorical criteria.

When using the presented clinical reference values of the MQO for orthopedic rehabilitation (WHO phase II) in Austria, apart from the reference sample, the monocentric character of the work has to be considered. The need for adjusting for different facility comparisons cannot be definitively answered. Different individual starting values must always be taken into account, as worse outcome parameters at the beginning of rehabilitation are accompanied by a greater potential for improvement (e.g., $r_{MQO} = -0.461$). Due to the prescribed performance profiles and the centrally controlled assignment modalities by the insurers, however, it can be assumed that the initial values presented and especially the changes in the MQO are representative of the inpatient rehabilitation of the musculoskeletal system in Austria.

The presented results and experiences of the clinical trial center suggest that the expected rehabilitation effects in the MQO factors are universal. Risk adjustment or indication- and group-specific modeling does not seem necessary. A closer characterization of nonresponders and types is still pending.

4.4. Limitation

The practical significance of the MQO outcomes or relationships with external criteria (endpoints), such as the incapacity for work, remains to be tested. Especially the global evaluation between MQO and sociomedical relevant external criteria is a potential further route for development. It is to be clarified which of the observed changes in MQO have significance for the sustainability of rehabilitative measures and to what extent optimized treatment pathways can influence them. Improvements in one outcome may well be accompanied by deterioration in other outcomes. Therefore, multidimensional approaches to the quality of results are always the methods of choice.

5. Conclusions

In addition to the usual "primary patient-oriented" assessment of quality of outcomes, the subjective assessment and satisfaction through self-reporting of patients as well as quality registers on surgical frequencies, length of stay and complications, these factors present a

valuable addition to the medical outcome quality evaluation. These can be essential for decision-making or can contribute to the design processes and further developments of quality assurance in rehabilitation facilities.

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Conflict of interest

The authors declare no conflict of interest.

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