ODNOS MED KRATKIM PRESEJALNIM PREIZKUSOM SPOZNAVNIH SPOSOBNOSTI IN IZIDOM REHABILITACIJE PO AMPUTACIJI SPODNJEGA UDA

RELATIONSHIP BETWEEN BRIEF COGNITIVE SCREENING AND REHABILITATION OUTCOMES AFTER LOWER LIMB AMPUTATION

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Abstract

Background:
Fitting of prosthesis after lower limb amputation (LLA) requires not only physical, but also cognitive capacity. Hence, we wanted to evaluate how Mini Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA) are associated with rehabilitation outcomes in patients after lower-limb amputation.

Methods:
Data from 155 patients (119 men; median age 69 years) after lower-limb amputation who had completed inpatient rehabilitation at the University Rehabilitation Institute in Ljubljana between September 2017 and February 2018 were analysed. Until January 2018, they were cognitively tested with MMSE (n=66), afterwards with MoCA (n=89). Primary study outcome was prosthesis fitting; secondary outcomes were ability to independently don the prosthesis, ability to independently climb stairs using the prosthesis, walking aid type and 6-minute-walk-test. Propensity-score-matching and regression models with matching variables as additional covariates were applied to adjust parameter estimates for group-imbalance. We also assessed how cognitive impairment cut-off agrees with the outcomes within each group.

Izvleček

Uvod:
Paciente po amputaciji spodnjega lahko v rehabilitaciji opremimo s protezo, za kar morajo imeti ustrezne telesne in spoznavne zmožnosti. Zato smo želeli ovrednotiti, kako sta Kratki preizkus spoznavnih sposobnosti (KPSS) in Montrealski spoznavni preizkus (MSP) povezana z izidi rehabilitacije pri pacientih po amputaciji spodnjega uda.

Metode:
Analizirali smo podatke o 155 pacientih (119 moških; sredinska starost 69 let) po amputaciji spodnjega uda, ki so bili na bolnišnični rehabilitaciji na URI Soča med septembrom 2017 in februarjem 2018. Do januarja 2018 so njihove spoznavne sposobnosti ocenjevali s KPSS (n=66), potem z MSP (n=89). Primarni izid rehabilitacije je bila uspešnost opremljanja s protezo; sekundarni izidi so bili zmožnost samostojnega nameščanja/snemanja proteze, zmožnost samostojnega vzpenjanja po stopnicah s protezo, vrsta pripomočka za hojo in dosežek na šestminutnem testu hoje. Uporabili smo uravnoteževanje na podlagi stopnje nagnjenosti (angl. propensity-score matching) in regresijske modele s spremenljivkami za uravnoteževanje kot dodatnimi napovednimi dejavniki; s tem smo ocene parametrov popravili za neuravnoteženost skupin. Ocenili smo tudi, koliko se pragovi za spoznavno okvaro skladajo z izidi znotraj vsake skupine.

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Results:
Regression models showed no statistically significant difference between the groups regarding association with the outcomes. MMSE/MoCA score was statistically significantly positively associated with prosthesis fitting and result of 6-minute-walk-test. Observed agreement of cognitive impairment based on MMSE/MoCA score cut-off with prosthesis fitting was higher in MMSE group; agreement with independent prosthesis donning and climbing stairs was higher in MoCA group. A ceiling effect was observed with MMSE scores.

Conclusion:
When adjusted for relevant patient characteristics, both MMSE and MoCA proved useful for predicting rehabilitation outcomes in patients after lower limb amputation.

Keywords:
rehabilitation outcome; amputation; prosthesis fitting; cognitive assessment

Rezultati:
Regresijski modeli niso pokazali statistično značilne razlike med skupinama glede povezanosti spoznavnega preizkusa z obravnavanimi izidi. Dosežek na KPSS oziroma MSP je bil statistično značilno pozitivno povezan z uspešnim opremljanjem s protezo in dosežkom na šestminutnem testu hoje. Opažena skladnost spoznavne okvare glede na prag dosežka z uspešnim opremljanjem s protezo je bila višja v skupini s KPSS; skladnost s samostojnim nameščanjem proteze in vzpenjanjem po stopnicah pa pa je bila višja v skupini z MSP. Pri dosežkih na KPSS smo opazili učinek stropa.

Zaključek:
Če ustrezno upoštevamo značilnosti pacientov, sta se oba preizkusa spoznavnih sposobnosti pokazala kot uporabna za napovedovanje izidov rehabilitacije pri pacientih po amputaciji spodnjega uda.

Ključne besede:
izid rehabilitacije; amputacija; opremljanje s protezo; ocenjevanje spoznavnih sposobnosti

INTRODUCTION

The loss of a limb has significant physical, psychological and social implications on a person's life (1). The principal goal of rehabilitation of patients after lower limb amputation (LLA) is to achieve mobility and maximum possible level of functioning and participation. To achieve that goal, a prosthesis may be fitted, but the fitting of a prosthesis is complex and requires not only physical, but also cognitive capacity to learn new skills and adapt them to different situations (2-4).

Cognitive function is often impaired in patients after LLA, which entails reasoning, psychomotor function, information processing, attention, memory, language/naming, visuospatial functions and executive functions (5). This cognitive impairment leads to poor functional outcomes, such as prosthesis use, mobility and community participation and social integration (4,6,7). Cognitive ability has been consistently found to be a significant predictor of walking ability after rehabilitation, with a superior outcome reported in those with better cognitive ability (8). It has been suggested that cognition is a moderately supportive factor for fitting prosthesis (9). Therefore, there is a need to use cognitive assessment as part of the initial assessment of patients after LLA to plan the rehabilitation (7).

Cognitive functioning after LLA has been operationalised and measured in a number of ways across various studies (2,3), from diagnosis of dementia to comprehensive neuropsychological assessment. The instruments used vary from screening tests, such as the Mini Mental State Examination (MMSE) (10,11) or the Montreal Cognitive Assessment (MoCA) (12,13), to specific tests for the elderly, such as the Kendrick Object Learning Test (KOLT) (7) or the Clifton Assessment Procedures for the Elderly (14,15). Among the tests of neuropsychological status, the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) (4,6) and the Addenbrookes Cognitive Examination (original ACE or the revised version ACE-R) (4,16) were most frequently used. The most comprehensive neuropsychological assessment reported comprised several standardised neuropsychological tests that took overall 3.5 hours to complete (5).

In the USA, the guidelines for rehabilitation of people after LLA (17) suggest "performing cognitive screening prior to establishing rehabilitation goals, to assess the patient's ability and suitability for appropriate prosthetic technology", but they do not specify what kind of test should be taken. They state that "future research is needed to specifically identify which cognitive tests provide predictive value while being practical for use in the clinic" (17). In the update, the clinical practice guideline on cognitive screening before establishing rehabilitation goals remains, but still without a specific cognitive screening test (18), which is also the case for other national guidelines for rehabilitation after amputation (19-22).

In general, cognitive screening assessment should be brief and sensitive to cognitive impairment. The Mini-Mental State Examination (MMSE) (23) is the most commonly used screening method in the assessment of the severity of dementia in both clinical and research field.(24,25) If the cut-off that defines normal cognitive function is set at 24 points, a meta-analysis of 15 studies indicated that it yields 85% sensitivity 90% specificity for prediction of dementia (26). In the Slovenian standardisation sample, the MMSE had 94% specificity and 53% sensitivity using that cut-off; the cut-off at 26 vs. 27 points resulted in 83% sensitivity and 66% specificity, and the authors suggested a cut-off at 25 vs. 26 points, which yielded 73% sensitivity and 75% specificity for prediction of dementia (27).

Although MMSE is an important tool in detecting early cognitive disorders (27), some researchers doubt the accuracy of this scale (28-30). Limitations of the MMSE as a screening tool for mild cognitive impairment contributed to the development of the Montreal Cognitive Assessment Scale (MoCA) (31). The original publication suggested the cut-off score for cognitive impairment at 26 points (31), but using a lower cut-off score of 23 points MoCA exhibited excellent sensitivity (96%) and specificity (95%) in a community sample (32). A meta-analysis concluded that MoCA meets the criteria for screening tests for the detection of mild cognitive impairment in patients over 60 years of age better than MMSE (30). For MoCA, the best cut-off for that purpose is 24 vs. 25 points (estimated sensitivity of 80% and specificity of 81%), while for MMSE it is 27 vs. 28 points (sensitivity 66%, specificity 73%) (30). Other studies also reported on the superiority of MoCA to MMSE in detection of patients with cognitive impairment that are at higher risk for development of dementia (33-36). MoCA has already been used with the LLA population, where it showed a significant association of test scores with functional mobility (12).

The aim of our study was to explore how cognition is associated with functional outcomes and which of the two cognitive screening measures, MMSE or MoCA, better predicts rehabilitation outcomes in patients after LLA. We assumed that cognition would influence the capacity to acquire the necessary skills for prosthesis fitting and use, including independent donning of the prosthesis, walking ability and endurance, i.e., that cognitive impairment would be associated with poorer functional outcomes. We also hypothesised that MoCA would better predict rehabilitation outcomes than MMSE because it is more sensitive to cognitive impairment.

METHODS

Our retrospective study addressed a cohort of 252 successive patients who completed rehabilitation at the University Rehabilitation Institute in Ljubljana between September 2017 and August 2018. The inclusion criteria were: first admission after uni- or bilateral transtibial or transfemoral amputation, 18 years of age or older and ability to complete cognitive screening. After exclusion of 97 patients (57 because of readmission, 14 because of transmetatarsal amputation or hip exarticulation, and 26 because of inability to complete the cognitive test due to severe vision impairment or writing impairment caused by rheumatism or polyneuropathy), complete data were collected from 155 patients.

The following information was abstracted from patient charts: age, sex, level of amputation, aetiology of amputation (diabetes, peripheral vascular disease, osteomyelitis or injury), MoCA or MMSE score, fitting with prosthesis (yes/no), independent prosthetic donning (yes/no), walking aid type (walker or crutches), ability to independently climb stairs using the prosthesis (yes/no) and 6-minute-walk-test (6mWT) (37). All the cognitive assessments were performed by the same psychologist (the first author); prosthesis use was assessed by a physiotherapist. The MoCA or MMSE was administered within the first three days after admission to the inpatient rehabilitation program. Until January 2018, the patients were tested with MMSE (66 patients) (23,38); afterwards, they were tested with MoCA (89 patients) (31). Prosthesis use was assessed within the last three days before discharge. All the tests were part of routine assessment during rehabilitation.

The study protocol was approved by the Research Ethics Committee of the University Rehabilitation Institute, Ljubljana, Slovenia (no. 26/2018). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Statistical analysis

Because of group-imbalance regarding sex, age, education level, level and cause of amputation, additional neurological disease and total number of diseases, propensity-score analysis was conducted. Imbalance was assessed in the total and matched sample using standardised differences (Cohen *d* or Cohen *h* for numerical or categorical variables, respectively), which were also estimated for the outcomes. Binary logistic regression (for the four binary outcomes) and multiple linear regression (for the numerical outcome) models with group-score interaction term were used to test whether MMSE and MoCA scores are differently associated with the outcomes in the matched sample. In those models, the outcome (success of prosthesis fitting, ability to independently don the prosthesis, ability to climb stairs, walking aid type – all binary; or the results of the 6mWT – numerical) was the dependent variable, while the independent variables were group (MoCA or MMSE), MMSE/MoCA score and the abovementioned interaction.

Additionally, analogous regression models were applied to all patients (henceforth referred to as complete sample) with the seven matching variables as additional independent variables (39). We also assessed (using Cohen κ) how the cut-off for cognitive impairment (≤25 points for MMSE, ≤17 points for MoCA) agrees with the four binary outcomes within each group. The data were analysed using IBM SPSS Statistics 27 (IBM Corp., Armonk, NY, USA).

RESULTS

All the patients tested with MMSE were successfully propensity-score matched with their MoCA counterparts, so the matched sample comprised 122 patients. The distribution of propensity score was practically identical in both groups in the matched sample (identical mean, median, SD and range to two decimals). In the matched sample, the patients were aged between 31 and 91 years (mean and median 69 years); 80% were men; 79% of the patients had high-school or higher education; 53% had transtibial amputation; 94% had a concomitant neurologic disease. Patients' characteristics are compared between the two groups within the total and matched sample in Table 1 using descriptive statistics and standardised differences (40).

The distribution of MMSE and MoCA scores (the latter in the total and matched sample) is shown in Figure 1. There were 23% of patients with MMSE indicating cognitive impairment (25 points or less). In the MoCA group, 93% of the patients in the total sample would have been classified as having at least mild cognitive impairment according to the originally proposed cut-off score of 26 points, and 94% in the matched sample. The suggested cut-off score for moderate cognitive decline of 18 points identified 31% and 30% of the patients in the total and matched sample, respectively, which was the criterion of cognitive impairment that we used for further analysis in the MoCA group.

In total, a prosthesis was fitted to 74% of the patients in the matched sample; among them, 91% could independently don the prosthesis, 83% could climb stairs and 80% used crutches rather than a walker. The average achievement on the 6mWT was 166m (range 30m to 420m). The observed outcomes are reported for each group in Table 2. Regression models using either matched or total sample showed no statistically significant difference between the groups regarding association with the outcomes ($p>0.1$ for interaction terms in Table 3). MMSE/MoCA score was statistically significantly associated with prosthesis fitting and the result of the 6mWT, but not with the ability to independently don the prosthesis, the ability to independently climb stairs or the walking aid type and (Table 3).

The observed agreement of absence of cognitive impairment with successful prosthesis fitting was clearly higher in the MMSE group (Cohen κ 0.48 vs. 0.13 in the MoCA group in the matched sample; Table 4). Conversely, the agreement of the cognitive impairment classification with independent prosthesis donning (Cohen κ 0.34 in the matched sample vs. 0.18 in the MMSE group) and climbing stairs (Cohen κ 0.33 in the matched sample vs. 0.14 in the MMSE group) was clearly higher in the MoCA group (Table 4). The agreement regarding type of walking aid was slightly higher in the MoCA group (Cohen κ 0.31 in the matched sample vs. 0.28 in the MMSE group; Table 4).

DISCUSSION

Our group of patients after LLA had high prevalence of cognitive impairment, which is concordant with previous research (5). However, MMSE reached a ceiling effect whereas the MoCA scores were much more evenly distributed (Figure 1), which implies that the MoCA is more sensitive to cognitive decline in the population of patients after LLA. Using the cut-off for moderate cognitive decline rather than the one that includes mild cognitive impairment for the analyses in the MoCA group therefore made the groups reasonably comparable in terms of prevalence of cognitive impairment.

Table 1. *Patient characteristics of the two groups in the total and matched sample.*
Tabela 1. *Lastnosti pacientov v obeh skupinah v celotnem in uravnoteženem vzorcu.*

Characteristic / Lastnost	MMSE / KPSS *(n=66)*	Total sample / Celotni vzorec: MoCA / MSP *(n=89)*	Total sample / Celotni vzorec: Standardised difference* / Standardizirana razlika*	Matched sample / Uravnoteženi vzorec: MoCA / MSP *(n=66)*	Matched sample / Uravnoteženi vzorec: Standardised difference* / Standardizirana razlika*
Sex (men) [women]	54 (82%)	65 (73%)	0.21	51 (77%)	0.11
Age: mean (SD)	68.4 (11.2)	71.3 (12.1)	-0.24	69.7 (11.7)	-0.11
Education level (high school or more) [elementary school or less]	52 (79%)	69 (78%)	0.03	52 (79%)	0.00
Amputation level (transtibial) [transfemoral]	34 (52%)	50 (56%)	-0.09	36 (55%)	-0.06
Cause of amputation (other) [diabetes]	43 (65%)	58 (65%)	0.00	38 (58%)	0.15
Neurological comorbidities (no) [yes]	62 (94%)	84 (94%)	-0.02	62 (94%)	0.00
Number of diseases: mean (SD)	3.2 (1.6)	3.6 (2.0)	-0.19	3.3 (1.7)	-0.02

Notes: MMSE – Mini Mental State Examination, MoCA – Montreal Cognitive Assessment; for binary variables, the more frequent category is listed in parentheses and its frequency and percentage are reported (the less frequent category is listed in square brackets); *MMSE minus MoCA, expressed as Cohen *d* or Cohen *h* for numerical or categorical variables, respectively.

Opombe: KPSS – Kratki preizkus spoznavnih sposobnosti; MSP – Montrealski spoznavni preizkus; za dvojiške spremenljivke je v okroglem oklepaju napisana pogostejša od obeh kategorij in zanjo navedena frekvenca in delež (redkejša kategorija je navedena v oglatem oklepaju); *KPSS minus MSP, izraženo kot Cohenov *d* za številske in Cohenov *h* za opisne spremenljivke.

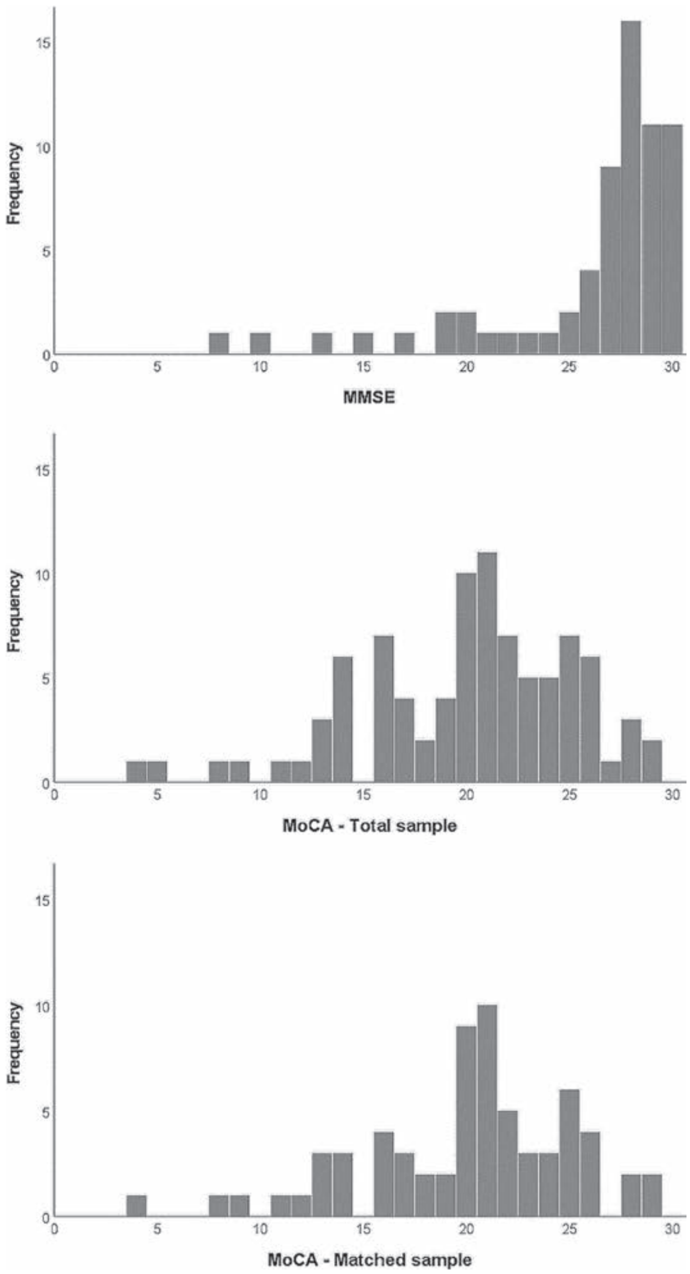

Figure 1. *Distribution of Mini Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA) scores.*

Slika 1. *Porazdelitev dosežkov na Kratkem preizkusu spoznavnih sposobnosti (angl. MMSE) in Montrealskem spoznavnem preizkusu (angl. MoCA; v celotnem in uravnoteženem vzorcu).*

Despite the relatively high prevalence of cognitive impairment in our sample, the majority of the patients (73% and 72% in the MMSE and MoCA group, respectively; Table 2) were fitted with a prosthesis. The decision whether to fit a prosthesis was namely made by the multiprofessional interdisciplinary team primarily based on cardiorespiratory function, comorbidities, the ability to independently stand up on one leg and the ability to walk in parallel bars. This implies that individuals with cognitive impairment are able to use a prosthesis, but may need more time to learn in and also more support in their everyday life.

Our first research aim was to explore how cognition is associated with functional outcomes. As expected (8,9), a higher cognitive test (MoCA or MMSE) score was associated with higher probability of being fitted with a prosthesis and longer distance walked during the 6mWT (Table 3). Prosthesis fitting is also cognitively demanding, especially after transfemoral amputation, and better cognition is linked to general better functioning (6), which in turn adds to the potential for being fitted with a prosthesis. The 6mWT is not cognitively difficult, but because all our patients were admitted to prosthetic rehabilitation for the first time, being able to walk required not only strength and endurance from them, but also appropriate gait technique and change of direction, which are cognitively quite demanding when wearing a prosthesis for the first time. In addition, the prosthesis gives no sensory feedback, and the patient has to control it with the residual limb.

Somewhat surprisingly, the results of cognitive testing were in general not clearly associated with the ability to independently don the prosthesis, the ability to independently climb stairs and the walking aid type (Table 3). These tasks are namely cognitively more demanding than the 6mWT. A possible reason for such results could be that the great majority of patients in our sample were able to function independently (details omitted). Furthermore, a general emphasis of our rehabilitation program is on patients who live alone learning to independently don the prosthesis, and on those who have stairs in their home environment to be able to climb them. Similarly, the primary selection criterion for the walking aid is patient's safety.

The second research question was which of the two tests better predicts the rehabilitation outcomes. There was no statistically significant difference between MMSE and MoCA scores regarding the association with any of the studied functional outcomes. However, when comparing observed agreement of the cut-off based classification of cognitive impairment with prosthesis fitting, there was much higher agreement in the MMSE group (Table 4). One possible explanation is that the clinicians in our rehabilitation program were more familiar with the MMSE and more aware of its threshold than it was the case with the newly introduced MoCA. Hence, MMSE scores might have had more influence on their decision whether to fit the patient with a prosthesis than MoCA scores. On the other hand, in the MoCA group the agreement was clearly higher with independent prosthesis donning and climbing stairs, and slightly higher regarding walking aid type (Table 4). These are all cognitive demanding tasks that require good attention, memorising the procedure and the ability to plan and follow the procedure. The MoCA test is more demanding than the MMSE as it is more saturated with memory functions, visuospatial and executive functions, and abstract thinking (30). This is also evident from the already discussed score distribution (Figure 1).

The main weakness of our study is its retrospective observational design with two groups of patients each performing its own cognitive screening test. In this way, we avoided the possibility of a learning effect (because MMSE and MoCA are quite similar), but exacerbated the problem of imbalance of the two groups in terms of relevant (demographic, health and other characteristics). This problem was surmounted by means of proportional score

Table 2. *Observed outcomes in the total and matched sample.*
Tabela 2. *Opaženi izidi v skupnem in uravnoteženem vzorcu.*

Outcome / Izid	MMSE / KPSS	MoCA Total sample / Celotni vzorec	MoCA Matched sample / Uravnoteženi vzorec
Prosthesis fitting (yes vs. no)	48/66 (73%)	64/89 (72%)	50/66 (76%)
Among those fitted with prosthesis			
Indep. donning of prosthesis (yes vs. no)	44/47 (94%)	54/64 (84%)	44/50 (88%)
Climbing stairs (yes vs. no)	40/45 (89%)	49/62 (79%)	37/48 (77%)
Walking aid (crutches vs. walker)	41/47 (87%)	47/64 (73%)	37/50 (74%)
6-minute-walk-test: *n*, mean (SD)	47; 185.5 (106.0)	63; 152.2 (85.2)	49;147.5 (81.7)

Notes: MMSE – Mini Mental State Examination, MoCA – Montreal Cognitive Assessment; for binary variables, the more frequent category is listed first and its frequency and percentage are reported.

Opombe: KPSS – Kratki preizkus spoznavnih sposobnosti; MSP – Montrealski spoznavni preizkus; za dvojiške spremenljivke je v oklepaju napisana pogostejša od obeh kategorij in zanjo navedena frekvenca in delež.

Table 3. *Summary of regression models.*
Tabela 3. *Povzetek regresijskih modelov.*

Model	Predictor / Napovedni dejavnik	Matched sample (using propensity scoring) / Uravnoteženi vzorec: *b*	(95% CI/IZ)	*p*	Total sample (model with additional predictors) / Celotni vzorec: *b*	(95% CI/IZ)	*p*
Prosthesis fitting (yes vs. no) – logistic regression (matched: $p<0.001$; total: $p<0.001$)*							
	Group (MoCA vs. MMSE)	4.33	(0.09, 9.52)	0.045	3.00	(-1.49, 8.68)	0.213
	MMSE/MoCA score	0.25	(0.12, 0.43)	<0.001	0.19	(0.03, 0.41)	0.017
	Interaction	-0.13	(-0.34, 0.05)	0.153	-0.08	(-0.31, 0.11)	0.414
Independent donning of prosthesis (yes vs. no) – logistic regression (matched: $p=0.007$; total: $p<0.028$)*							
	Group (MoCA vs. MMSE)	-0.20	(-9.12, 8.07)	0.962	0.90	(-8.47, 9.13)	0.829
	MMSE/MoCA score	0.23	(-0.07, 0.52)	0.119	0.22	(-0.12, 0.52)	0.171
	Interaction	0.08	(-0.28, 0.46)	0.661	0.00	(-0.34, 0.38)	0.982
Climbing stairs (yes vs. no) – logistic regression (matched: $p=0.015$; total: $p=0.002$)*							
	Group (MoCA vs. MMSE)	-1.44	(-13.94, 8.39)	0.779	-2.63	(-20.55, 9.04)	0.700
	MMSE/MoCA score	0.14	(-0.29, 0.48)	0.469	-0.01	(-0.67, 0.40)	0.965
	Interaction	0.09	(-0.30, 0.55)	0.664	0.10	(-0.35, 0.75)	0.691
Walking aid (crutches vs. walker) – logistic regression (matched: $p=0.001$; total: $p<0.001$)*							
	Group (MoCA vs. MMSE)	-0.28	(-7.87, 7.50)	0.939	1.62	(-6.55, 9.40)	0.674
	MMSE/MoCA score	0.20	(-0.05, 0.47)	0.107	0.22	(-0.06, 0.51)	0.117
	Interaction	0.05	(-0.26, 0.35)	0.752	-0.04	(-0.36, 0.29)	0.802
6-minute-walk-test (m) – linear regression (matched: $p=0.001$, $R2a=0.16$; total: $p<0.001$, $R2a=0.34$)**							
	Group (MoCA vs. MMSE)	191.4	(-156.4, 539.3)	0.215	162.0	(-148.8, 472.9)	0.240
	MMSE/MoCA score	14.3	(5.1, 0.8)	0.006	8.3	(-2.7, 19.2)	0.090
	Interaction	-6.3	(5.8, -0.7)	0.280	-5.9	(-17.5, 5.8)	0.255

Notes: *with Firth bias correction, *p*-value for the model from likelihood-ratio test; ***p*-value for the model from ANOVA, $R2a$ = adjusted coefficient of determination = estimated proportion of explained variation in the population; MMSE – Mini Mental State Examination, MoCA – Montreal Cognitive Assessment; *b* – unstadardised regression coefficient, CI – confidence interval.

Opombe: *s Firthovim popravkom za pristranost, vrednost *p* iz testa razmerja verjetij; **vrednost *p* za model kot celoto; KPSS – Kratki preizkus spoznavnih sposobnosti, $R2a$ = popravljeni determinacijski koeficient = ocenjeni delež pojasnjene variance v populaciji; MSP – Montrealski spoznavni preizkus; *b* – nestandardiziran regresijski koeficient, IZ –interval zaupanja.

Table 4. *Observed agreement of the cut-off for cognitive impairment with the outcomes.*
Tabela 4. *Opažena skladnost praga za spoznavno okvaro z izidi.*

		MMSE / KPSS			MoCA – Total sample / MSP – Celotni vzorec			MoCA – Matched sample / MSP – Uravnoteženi vzorec		
Outcome / Izid		**Below cut-off / Pod pragom**	**Above cut-off / Nad pragom**	**Cohen κ**	**Below cut-off / Pod pragom**	**Above cut-off / Nad pragom**	**Cohen κ**	**Below cut-off / Pod pragom**	**Above cut-off / Nad pragom**	**Cohen κ**
Prosthesis fitting	yes	5	43	0.48	16	48	0.15	12	38	0.13
	no	10	8	(p<0.001)	10	15	(p=0.198)	6	10	(p=0.340)
Independent donning of prosthesis	yes	4	40	0.18	10	44	0.33	8	36	0.34
	no	1	2	(p=0.292)	6	4	(p=0.012)	4	2	p=0.024)
Climbing stairs	yes	3	37	0.14	8	41	0.29	4	32	0.33
	no	1	4	p=0.387)	6	7	(p=0.032)	5	6	(p=0.036)
Walking aid	crutches	3	38	0.28	8	39	0.31	6	31	0.31
	walker	2	4	p=0.115)	8	9	(p=0.021)	6	7	p=0.055)

Notes: MMSE – Mini Mental State Examination, below cut-off (mild cognitive impairment) ≤ 25 points, above cut-off ≥ 26 points; MoCA – Montreal Cognitive Assessment, below cut-off (moderate cognitive impairment) ≤ 17 points, above cut-off ≥ 18 points.

Opombe: KPSS – Kratki preizkus spoznavnih sposobnosti, pod pragom (blaga spoznavna okvara) ≤ 25 točk, nad pragom ≥ 26 točk; MSP – Montrealski spoznavni preizkus, pod pragom (zmerna spoznavna okvara) ≤ 25 točk, nad pragom ≥ 26 točk.

matching (40), as evidenced by the standardised differences being practically reduced to zero after the matching (except for cause of amputation; Table 1). In addition, the alternative approach of regression models applied to the total sample with the characteristics in question as additional covariates led to equivalent conclusions as the regression models applied to the matched sample (Table 3), which speaks in favour of validity of our conclusions.

The heterogeneity of causes of amputation can be seen as a strength (because of better generalisability of the findings to the entire population of patients after LLA), as well as a limitation of our study (because larger variability lowers the power of statistical comparisons). In any case, it reflects the variability of diagnoses of the patients who are admitted to inpatient rehabilitation after LLA. In addition, the 26 excluded patients who could not complete the cognitive test were evenly distributed between the two groups (14 MMSE, 12 MoCA), thus the risk of selection bias was low. Another strength of our study is the relatively large sample of amputees consecutively admitted to the rehabilitation unit.

Future research might focus on the implications of cognitive ability for everyday functioning after rehabilitation (i.e., daily activities, community participation and social integration), as well as on the ways to optimise the process of learning to use the prosthesis while taking cognitive impairment into account.

CONCLUSION

When adjusted for relevant patient characteristics, both MMSE and MoCA proved useful for predicting rehabilitation outcomes after lower limb amputation. MMSE may be more appropriate for predicting prosthesis fitting, while MoCA may be better suited to predict ability to independently don the prosthesis and climb stairs among those fitted with prosthesis. Overall, our study confirmed that rehabilitation inpatients after lower limb amputation should be routinely cognitively screened.

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