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Electromyographic Study of Muscular Activity in the Amputation Stump While Walking with PTB- and PTB-suction Prosthesis

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ABSTRACT

A comparative electromyographic study of the muscular activity while walking with PTB and PTB-suction prosthesis is presented. The PTB-suction prosthesis has been used clinically since 1969 with generally promising results. This prosthesis is mainly of value for patients with skin problems (poor sensibility and contact sores) and also has a cosmetic advantage. The present investigation has demonstrated that there is frequently a muscular activity pattern when walking with the PTB-suction prosthesis which is similar to that of a normal leg. The PTB prosthesis often shows a pattern of simultaneous contractions of antagonistic muscles. Furthermore, when the EMG-pattern is more "normal" and the amplitude higher with the PTB-suction prosthesis, it is probably the more suitable prosthesis. These EMG investigations can thus be a possible adjunct in the selection between the PTB-suction prosthesis and PTB prosthesis.

INTRODUCTION

The PTB prosthesis (PTB=Patella Tendon Bearing) (1) suits the needs of about 90% of BK (BK=Below knee) amputees (2). Some patients when using the PTB prosthesis have a sense of instability. In addition, some patients develop contact sores after prolonged use. These problems called for an alternative suspension for the BK amputee.

In 1969 a team consisting of staff of the Department of Orthopaedic Surgery and Een & Holmgren Inc. began a clinical trial with a suction type of PTB prosthesis (PTB-S) as an analogue to the abovementioned suction prosthesis. The preliminary results were reported by Grevsten & Marsh in 1971 (3). To evaluate the PTB-suction prosthesis the following tests were carried out earlier: (i) A roentgenological study to analyse the relationship between the amputation stump and the prosthesis socket in various static positions imitating stride moments (4), and (ii) an evaluation of the pressure variations between the stump and the socket wall while walking with the prosthesis (5).

In the same laboratory EMG-recordings have previously been made from the remaining muscles on BK-stumps while walking with an ordinary PTB prosthesis (8, 9). It was reported that antagonistic muscles were often activated simultaneously in the stance phase of the prosthetic leg, a pattern not seen during normal gait.

The present electromyographic investigation was undertaken with the aim of comparing activity of the stump muscles without prosthesis and when using the PTB and PTB-suction prostheses. In the muscular pattern, three components have been separated for investigation:

1. Voluntary contraction of the stump muscles without prosthesis.
2. Activity pattern of the antagonistic muscles while walking, and
3. Amount of muscular activity in the stump muscles while walking.

MATERIAL AND METHODS

Patients

Nine otherwise healthy men (average age 42 years, range 34–51 years) with BK amputation (unilateral in 8 and bilateral in 1) were studied. All subjects were fitted with PTB as well as PTB-suction prosthesis at the time of investigation and were accustomed to both types of prosthesis (see clinical data). The period between amputation and investigation varied between a few months and 5 years. One control subject was investigated with these techniques to verify its reproducibility during normal gait (6).

Technical comments on the prosthesis

The evaluation of the fit of the prosthesis was carried out in collaboration with a qualified prosthetist (L. Marsh).

Fig. 1. The fixation of the surface electrodes.

The PTB prosthesis was constructed according to Radcliffe & Foort (1961) (1). The PTB-suction prosthesis was initially constructed with a non-detachable inner socket. Later the suction prosthesis was made with a detachable, semirigid inner part. The present investigation took place during the period when the construction was changed. The two different PTB-suction prostheses are separated in the results (Table II).

Clinical data

The PTB prosthesis was used variably by the different patients. Some used the PTB prosthesis as the primary one and the PTB-suction prosthesis occasionally. Other patients preferred the PTB-suction prosthesis and used the PTB prosthesis less often.

The clinical follow-up of the patients using the PTB-suction prosthesis was done at intervals of 1, 3 and 6 months, 1 year and then once a year. The longest observation time was 5 years. Information was recorded concerning the extent of prosthesis usage, feeling of safety with the prosthesis and skin status, especially considering the sore problems.

EMG technique

The EMG was recorded bipolarly between two surface electrodes fixed 10 cm below the knee over the tibialis anterior muscle and between two electrodes fixed over the medial portion of the gastrocnemius muscle. Similar recordings were performed both on the amputated and healthy sides. The ground electrode was placed over the proximal part of the tibia (see Fig. 1). Four identical EMG amplifiers were enclosed in two boxes (3×4×6 cm) which were fixed to the waist. The frequency response was 100–1 000 Hz. The EMG was rectified and integrated with a time constant of 0.1 sec. The EMG channels and the 4 corresponding integrated traces were recorded on a polygraph (modified Elema-Schönander EEG-apparatus) (Fig. 2). On two other channels, signals from toe or heel contacts on the shoes were recorded.

Test of voluntary muscular activation (without the prosthesis)

The patient sat in a chair. Recordings were made from tibialis anterior muscle and gastrocnemius muscle while the patient performed maximal and sustained voluntary contractions.

Gait model during the EMG-investigations

The EMG-investigations were made with the patient walking on a tread-mill. The walking speed was set at 25 m/min and 45 m/min with the treadmill horizontal (Fig. 2). The step frequency was spontaneously determined by the patient.

Evaluation of the EMG-recordings

Conventional EMG-recording. The relationship between the activity pattern in gastrocnemius and tibialis anterior muscles was determined with the initiation of muscular activity in gastrocnemius muscle used as the reference. The gastrocnemius muscle activity and the just preceeding or simultaneously occurring tibialis anterior muscle activity was considered to belong to the same walking cycle. Thirty walking cycles were studied. The time difference between the initiation of muscular activity in the two

Fig. 2. The electromyographic recorder, a modified Elema-Schönander EEG-apparatus.

antagonistic muscles was measured and the contraction pattern noted. The same procedure was performed on the healthy and amputated sides.

Integrated EMG. The integrated EMG is a measure of the amount of EMG-activity per unit time. The maximum height (Max in Table II) of the integrated EMG-recording was measured from each of 30 consecutive cycles. Ongoing activity was often present in the stump muscles. Thus the difference between the maximal amplitude and ongoing activity was also measured (Diff. in Table II). Only measurements from the gastrocnemius muscles are presented (walking with prostheses). The recordings from the tibialis anterior muscles were often of low amplitude and could not be sufficiently analysed in detail in all cases.

RESULTS

Voluntary contractions without prosthesis

All patients were able to activate both muscle groups separately with voluntary sustained contractions. A full interference pattern was noted. The EMG-amplitudes were nearly equal for the two muscle groups. In comparison with the normal side, the difference was much smaller with this type of contraction than during gait.

Muscular activity while walking with PTB prosthesis

The EMG-investigation of the tibialis anterior and the gastrocnemius muscles while walking demonstrated a high occurrence of simultaneous contraction in the antagonistic muscles (Table I).

Simultaneous muscle contractions were found in six of the ten patients at a walking speed of 25 m/min and in 9 of them at a speed of 45 m/min (See Table I and Fig. 3).

The normal activity pattern is markedly changed. The simultaneous contraction of the antagonistic muscles occurs during the greatest load on the

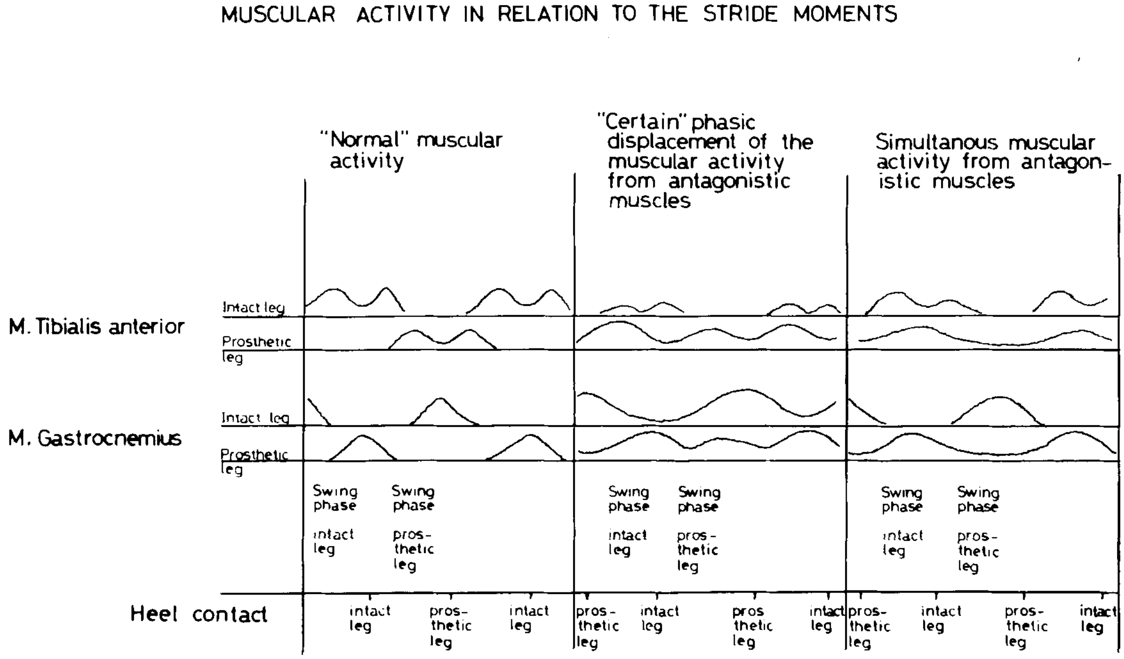

Fig. 3. A schematic description of the most common muscular activity while walking with PTB-prosthesis (simultaneous muscular activity from antagonistic muscles) and PTB-suction prosthesis ("Normal muscular activity"). In the "normal" muscular activity there is often seen a base tone and sometimes a second contraction of muscular gastrocnemius.

prosthesis and has its maximum activity when the other leg is in its swing phase. The two muscles demonstrate only a single activation.

Muscular activity while walking with PTB-suction prosthesis

While walking with PTB-suction prosthesis most of the EMG recordings showed a different activity pattern of the stump muscles than when the PTB prosthesis was used.

With the PTB-suction prosthesis the two muscles showed simultaneous contraction in two of the ten legs at a speed of 25 m/min and in four of nine cases at 45 m/min.

Some patients showed a relatively normal muscular activity pattern. Others had increased ongoing activity in the stump and additional ones demonstrated prolonged normal activity patterns occasionally in association with increased ongoing activity. At times, double contractions of the gastrocnemius were seen. The main contraction occurs in its normal moment during the stance phase and the smaller one in the middle of the swing phase.

The mean value of the integrated EMG-recordings for 30 consecutive gait cycles at walking speed of 25 m/min and 45 m/min were determined (Table II*A* and *B*). At 25 m/min five of the ten stumps had increased activity with the PTB-suction prosthesis (PTB-S-sign) compared with the PTB-prosthesis. With four stumps there was

Table I. *Phasic relations between the muscle contractions in m. tibialis anterior and m. gastrocnemius while walking with PTB- and PTB-suction prosthesis*

"Normal" phasic relation=the same phasic relations which exist on the intact leg. The figures in the table denote number of legs

Walking speed	Simultaneous contraction of antagonistic muscles	"Certain" phasic displacement	"Normal" phasic relation
PTB-prosthesis			
25 m/min	6	2	2
45 m/min	9	0	1
PTB-suction prosthesis			
25 m/min	2	2	6
45 m/min	4	0	5

greater muscular activity with the PTB-prosthesis (PTB-sign) and in one stump the difference was insignificant. At 45 m/min seven out of ten stumps had greater muscular activity with the PTB-suction prosthesis than with the PTB. For the other three cases, the muscular activity was greater with the PTB prosthesis which was extremely well fitted.

In Table III a comparison is made of the two prostheses relative to the muscular activity pattern and the amount of muscular activity. Using the PTB-suction prosthesis the patients with a significantly increased muscular activity in the PTB-suction prosthesis (PTB-S-sign) more often had normal muscular activity than those patients with significantly more muscular activity in the PTB prosthesis (PTB-sign). When the "PTB-S-sign" patients use the PTB prosthesis the pattern is changed from "normal" to "simultaneous contraction" in most of the cases. The same change is seen in all the "PTB-sign" patients. Thus, the activity pattern is more often "normal" in the PTB-suction prosthesis than in the PTB prosthesis. This is true for both "PTB-S-sign" and "PTB-sign" patients.

Adaptability to the PTB-suction prosthesis

Table IV shows the adaptation to the prostheses in relation to the muscular activity pattern. Patients who had a "normal" muscular activity pattern in the PTB-suction prosthesis more often were later adapted to this prosthesis. Patients with "simultaneous" activity in the PTB-suction prosthesis were later satisfied with the PTB prosthesis.

DISCUSSION

In order to compare the two prostheses a basic problem is to have the patients equally adapted to both types. Patients well suited with one of the prostheses are hesitant to use the other. In addition to psychological reasons and training effects the soft tissue of the stump is treated differently with the two sockets. In the PTB-suction prosthesis the soft tissue is *pulled* down towards the bottom of the inner socket which is correspondingly slightly widened distally. With the conventional PTB prosthesis the amputation stump is covered with a stocking and *pushed* down into the socket. Thus, in the latter case the soft tissue is not concentrated at the end of the stump but is more proximally displaced.

These differences in the distribution of the soft tissue causes permanent changes in the shape of the stump. Therefore it is somewhat difficult to change to another prosthesis after prolonged use.

Some of the patients using the PTB-suction prosthesis as the primary one use the PTB prosthesis occasionally, especially during sporting activities such as skiing and running where the PTB-suction prosthesis may be less suitable. The juxtaposition of the limb within the socket under extreme combinations of loading and knee flexion can break the seal, causing loss of suction (5). This problem is less pronounced with the detachable semirigid inner socket.

Patients using the PTB prosthesis as the primary one may occasionally for cosmetic reasons use the PTB-suction prosthesis (usually women).

In spite of the above-mentioned problems the patients in the present study have been chosen from those using both prostheses. The patient is thus his own control. The EMG-recordings from the different patients vary because of differing remaining muscle mass and fixation, electrode position, skin resistance and recording factors. These parameters are relatively constant during the individual recording and also with consecutive recordings in the same patient. The reproducibility is seen in Table II A and II B, where patients have been investigated with the two prostheses alternatively.

In the normal muscle the integrated EMG is mainly proportional to the muscle force (7). In the present investigation it was not intended to measure the muscle force, but to use the integrated EMG as a measure of the degree of muscular activation during walking.

EMG-investigations of amputation stumps are of both practical and theoretical interest. EMG-activity has been used in order to steer prostheses and other appliances for the handicapped. Analysis of the muscular activity pattern in amputees is of importance to determine the function of the prosthesis, especially in evaluating cases where there are difficulties in walking with the prosthesis. An abnormal muscular pattern can be attributed to poor fixation of the prosthesis but may also be a sign of disturbed reflex control of the extremity due to altered proprio- and exteroceptive signals.

Earlier EMG-investigations have been performed on non-denervated stump muscles in patients with BK-amputation using PTB prosthesis (8, 9). They showed, contrariwise, a high frequency of reduced

Table II A. *Integrated EMG activity measured on m. gastrocnemius in PTB and PTB-suction prosthesis (walking speed 25 m/min)*

+ = Later adapted to PTB-suction prosthesis, 0 = PTB and PTB-suction prostheses are used alternatively at later follow-ups, − = Later adapted to another prosthesis than PTB-suction

Patient	Birth year	PTB prosthesis Integrated EMG		PTB-suction prosthesis (non-detachable inner socket) Integrated EMG		PTB-suction prosthesis (detachable inner socket) Integrated EMG	
		Max	Diff	Max	Diff	Max	Diff
S. D.	37	*M*=5.16 S.E.=0.23	*M*=3.93 S.E.=0.24			*M*=9.56 S.E.=0.17	*M*=7.13 S.E.=0.17
K. M.	38	*M*=2.43 S.E.=0.16	*M*=2.43 S.E.=0.16	*M*=9.63 S.E.=0.43	*M*=9.63 S.E.=0.43		
E. J.	21	*M*=6.73 S.E.=0.34 *M*=5.26 S.E.=0.24	*M*=5.60 S.E.=0.34 *M*=4.83 S.E.=0.24			*M*=11.06 S.E.=0.22 *M*=12.13 S.E.=0.17	*M*=10.06 S.E.=0.22 *M*=11.13 S.E.=0.22
J. B.	38	*M*=8.30 S.E.=0.38 *M*=8.48 S.E.=0.74 *n*=27	*M*=7.40 S.E.=0.40 *M*=8.48 S.E.=0.74	*M*=21.16 S.E.=0.67	*M*=18.46 S.E.=0.75		
H. L.	37	*M*=3.46 S.E.=0.20	*M*=3.46 S.E.=0.20	*M*=6.00 S.E.=0.20	*M*=5.23 S.E.=0.20		
J. H.	24	*M*=20.83 S.E.=1.18	*M*=20.17 S.E.=1.31			*M*=7.87 S.E.=0.49	*M*=6.40 S.E.=0.57
L. L.	25	*M*=8.80 S.E.=0.14	*M*=8.80 S.E.=0.14	*M*=6.76 S.E.=0.17	*M*=6.76 S.E.=0.17		
J. E. P.	21	*M*=18.13 S.E.=1.08	*M*=17.05 S.E.=0.96			*M*=17.97 S.E.=1.31	*M*=17.97 S.E.=1.31
K. O. E	30	*M*=5.16 S.E.=0.10 *n*=49	*M*=3.53 S.E.=0.10	*M*=4.20 S.E.=0.18	*M*=2.70 S.E.=0.22		
K. O. E.	30	*M*=5.66 S.E.=0.23	*M*=5.33 S.E.=0.23	*M*=3.03 S.E.=0.03	*M*=1.96 S.E.=0.03		

PTB-S-sign means that PTB-suction prosthesis has significantly more integrated EMG activity.
PTB-sign means that PTB prosthesis has significantly more integrated EMG activity.
* = $0.01<P<0.05$. ** = $0.001<P<0.01$. *** = $P<0.001$.
The number (*n*) of measured consecutive muscle activation was 30 except in a few instances which are marked in the table.

voluntary activation of the muscle along with inability of selective activation of one of the antagonistic muscles of the stump. They found, as we have, a high frequency of simultaneous contraction of the antagonistic muscles during gait.

Muscular activity pattern while walking with intact legs

In the intact leg the tibialis anterior muscle contracts in the beginning of the swing-phase (when the toe is lifted) and in the beginning of the stance phase (just before and just after the heel contact). The gastrocnemius muscle is contracted only once in normal gait, when the foot is extended dorsally (i.e. the last moment of the stance phase) (6).

Muscular activity pattern while walking with PTB prosthesis

In the PTB prosthesis a high frequency of simultaneous contraction of antagonistic muscles was found. The piston action is a well documented event in the PTB prosthesis and is due to a loose suspension (10, 11). Rotational movement and the downward displacement act together in the socket under weight bearing, resulting in a regular trauma which causes sores on critical skin areas (12, 13, 14, 15, 16). It can therefore be assumed that the recorded simultaneous contraction of antagonistic muscles in the stance phase is a defence mechanism to reduce the effect of this regular traumatism.

Difference in integrated EMG activity*		Later adaptation to PTB-suction prosthesis
Max	Diff	
PTB-S-sign. ***	PTB-S-sign ***	+
PTB-S-sign. ***	PTB-S-sign ***	+
PTB-S-sign. ***	PTB-S-sign ***	+
PTB-S-sign. ***	PTB-S-sign ***	+
PTB-S-sign. ***	PTB-S-sign. ***	0
PTB sign. ***	PTB sign. ***	0
PTB sign. ***	PTB sign. ***	0
No. sign.	No. sign.	–
PTB sign. ***	PTB sign. ***	–
PTB sign. ***	PTB sign. ***	–

Muscular activity pattern while walking with PTB-suction prosthesis

The relatively normal activity pattern with the PTB-suction prosthesis may have two possible explanations:

(i) The technique of fixation in the PTB-suction prosthesis may bring about defence reactions from the stump to maintain it in a fixed position in the socket. These defence reactions may coincidently be in step with the normal activity pattern in an intact leg. The defence reaction is intended to completely abolish the effect of forward angulation of the tibia in the soft tissue (4) during the stance phase and to increase the stability of fixation during the swing phase. The two-peak activity found in the tibialis anterior muscle of amputees is similar to normals. The above explanation may not really suffice.

(ii) The other explanation for the relatively normal muscular activity pattern is that the muscles are influenced by normal spinal reflexes. These reflexes remain after amputation of the foot as long as normal afference persists, mainly from the muscle spindles, and the fixed prosthesis does not give irregular and drastic sensory input, such as a piston action, which may change the activity pattern.

In the PTB-suction prosthesis the stump is smoothly adapted to the socket and the piston action is reduced. The reflex pattern is not supported by normal afferent activity from the leg but is probably not unduly disturbed by the strong abnormal afference.

The observed differences between the muscular activity for amputees and normals may be due to differing afferent input in the amputation stump from that in normals.

The defined ongoing activity observed in the stump with the applied prosthesis is probably due to feelings of insecurity and thus is a muscular defence to retain the prosthesis. This feeling of insecurity with this prosthesis (without external fixation) can remain for several months.

The pattern of "certain abnormality" is an intermediate group containing the recordings which were difficult to place in the group of normal activity but which have a pattern in the recordings clearly differing from the defined simultaneous antagonistic activity.

The simultaneous contraction of antagonistic muscles seen especially at faster walking speeds may be a defence reaction and is induced by the increasing insecurity at the higher speeds.

Adaptability of the PTB-suction prosthesis

All but one of the patients with higher muscular activity with the PTB suction prosthesis (PTB-S-sign walking speed 25 m/sek) also preferred this prosthesis at later follow-ups. The remaining patient uses this prosthesis occasionally. Seven patients had higher muscular activity with the PTB-suction prosthesis (PTB-S-sign walking speed 45 m/sek): four preferred the prosthesis at later controls. Two use it occasionally, and one has chosen the PTB prosthesis as the only one. It should also be noted that the three patients who had increased muscular activity with the

Table IIB. *Integrated EMG activity measured on m. gastrocnemius in PTB and PTB-suction Prosthesis (walking speed 45 m/min)*

+ =Later adapted to PTB-suction prosthesis, 0=PTB and PTB-suction prosthesis are used alternately at later follow-ups, − =Later adapted to another prosthesis than PTB-suction

Patient	Birth year	PTB prosthesis Integrated EMG		PTB-suction prosthesis (non-detechable inner socket) Integrated EMG		PTB-suction prosthesis (detechable inner socket) Integrated EMG	
		Max	Diff	Max	Diff	Max	Diff
S.D.	37	*M*=8.47 S.E.=0.19	*M*=6.17 S.E.=0.20			*M*=9.37 S.E.=0.17	*M*=6.70 S.E.=0.21
K.M.	38	*M*=10.40 S.E.=0.99	*M*=10.40 S.E.=0.99	*M*=13.63 S.E.=0.96	*M*=13.63 S.E.=0.86		
E.J.	21	*M*=4.03 S.E.=0.14	*M*=2.93 S.E.=0.17			*M*=13.40 S.E.=0.28	*M*=10.96 S.E.=0.30
J.B.	38	*M*=6.33 S.E.=0.26	*M*=4.66 S.E.=0.26	*M*=22.70 S.E.=0.58	*M*=20.53 S.E.=0.60		
		M=5.30 S.E.=0.55	*M*=5.13 S.E.=0.53				
H.L.	37	*M*=3.46 S.E.=0.15	*M*=3.46 S.E.=0.15	*M*=5.26 S.E.=0.14	*M*=4.26 S.E.=0.14		
J.H.	24	*M*=16.50 S.E.=1.24	*M*=14.90 S.E.=1.24			*M*=5.00 S.E.=0.26	*M*=3.90 S.E.=0.24
L.L.	25	*M*=7.23 S.E.=0.18	*M*=7.23 S.E.=0.18	*M*=7.86 S.E.=0.17	*M*=7.86 S.E.=0.17		
J.E.P.	21	*M*=23.41 S.E.=0.50	*M*=20.10 S.E.=0.42			*M*=30.10 S.E.=0.68	*M*=27.23 S.E.=0.72
K.O.E.	30 left	*M*=4.68 S.E.=0.00	*M*=4.02 S.E.=0.00 *n*=83	*M*=3.89 S.E.=0.10	*M*=2.33 S.E.=0.10 *n*=57		
				M=3.63 S.E.=0.10	*M*=1.95 S.E.=0.10 *n*=41		
K.O.E.	30 right	*M*=5.30 S.E.=0.12	*M*=5.30 S.E.=0.12	*M*=3.60 S.E.=0.10	*M*=2.53 S.E.=0.10		

PTB-S-sign. means that PTB-suction prosthesis has significantly more integrated EMG activity.
PTB-sign. means that PTB prosthesis has significantly more integrated EMG activity.
* =0.01<*P*<0.05. ** =0.001<*P*<0.01. *** =*P*<0.001.
The number (*n*) of measured consecutive muscle activations were 30 except in few instances which are marked in the table.

PTB prosthesis (PTB-sign) at both walking speeds also preferred the PTB prosthesis at later controls.

Thus, those patients demonstrating greater muscular activity with a particular prosthesis tend to use that prosthesis for continued use. The activity pattern in PTB-suction prosthesis is more often "normal" than with PTB prosthesis, irrespective of whether the amount of muscular activity is "PTB-S-sign" or "PTB-sign".

A normal muscular activity pattern in the PTB-suction prosthesis is correlated to better adaptability to this prosthesis. The defined simultaneous muscular activity in the PTB-suction prosthesis is correlated with a greater adaptation to the PTB prosthesis.

The findings suggest that "normal" EMG-pattern in the PTB-suction prosthesis with high amplitude is associated with improved adaptation to this prosthesis.

In conclusion, the EMG investigations can be of assistance when selecting the most desirable prosthesis for the individual patient (17).

ACKNOWLEDGEMENTS

The collaboration of the prosthetist Lennart Marsh is gratefully acknowledged. The investigation was made

Difference in integrated EMG activity*		Later adaptation to PTB-suction prosthesis
Max-	Diff	
PTB-S-sign. ***	PTB-S-sign. *	+
PTB-S-sign. *	PTB-S-sign. **	+
PTB-S-sign. ***	PTB-S-sign. ***	+
PTB-S-sign. ***	PTB-S-sign. ***	+
PTB-S-sign. ***	PTB-S-sign. **	0
PTB-sign. ***	PTB-sign. ***	0
PTB-S-sign. **	PTB-S-sign. **	0
PTB-S-sign. ***	PTB-S-sign. ***	–
PTB-sign. ***	PTB-sign. ***	–
PTB-sign. ***	PTB-sign. ***	–

Table III

Amount of muscular activity	Walking speed (m/min)	Normal	"Certain" phasic displacement	Simultaneous contraction of antagonistic muscles
Muscular activity pattern in PTB-S prosthesis				
PTB-S-sign.	25	4	1	
	45	5		2
PTB-sign.	25	2	1	1
	45	1		2
Muscular activity pattern in PTB prosthesis				
PTB-S-sign.	25	2		3
	45	1		6
PRB-sign.	25		2	2
	45			3

The figures in the table denote number of legs.

Table IV. *Adaptability to PTB-suction prosthesis in relation to the muscular activity pattern*

		Later adapted to:	
Muscular activity pattern in PTB-S prosthesis	Walking speed (m/min)	PTB-S prosthesis	PTB prosthesis
Normal	25	4	2
	45	3	2
"Certain" phasic displacement	25		2
	45		
Simultaneous contraction of antagonistic muscles	25		2
	45	1	4

The figures in the table denote number of legs.

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