

Research into the effect of the treatment of the carpal tunnel syndrome with the Phystrac traction device

Research carried out in commission of:
Fysiotherapie Centrum Zuidwolde
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Foreword

This research has been carried out on commission of Fysiotherapie Centrum Zuidwolde. About 1 year ago they purchased a Phystrac traction device for the treatment of carpal tunnel syndrome. During this year questionnaires were conducted with all patients who were under treatment with the Phystrac traction device for carpal tunnel syndrome and power measurements were taken for the evaluation of the treatment.

In order to get an impression of the first effects of these treatments within the practice, I have been asked to analyse these questionnaires.

Because the questionnaires were first conducted for the evaluation of the individual treatments and not for the purpose of scientific research, they were not conducted according to strictly outlined guidelines. Therefore no definitive scientific conclusions can be attached to the research.

The objective of Fysiotherapie Centrum Zuidwolde is therefore to get an impression of the effects of these treatments up to now, and possible factors which have an influence, for the personal practice, not for scientific publication. The report is thus also written within this framework, directed at employees of Fysiotherapie Centrum Zuidwolde.

Hereby I would like to thank Ay yin Ang, Reinier Havinga, Bert Huizing, Marianne Kombrink, Roel Schoemaker, and Ingrid Schoemaker for commissioning me for this research, which I have carried out with a lot of pleasure, for their help and interest in the results.

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Winsum, September 2006

Summary

About 1 year ago Fysiotherapie Centrum Zuidwolde purchased a traction device for the treatment of carpal tunnel syndrome. Questionnaires (Levine, 1993; ned. Versie [Dutch version]) were conducted with all patients which were being treated for carpal tunnel syndrome with the Phystrac traction device, and power measurements were taken for the evaluation of the treatment. This research has been carried out in order to determine what the effect of these treatments in the past year has been.

The objectives of this research are: 'the determination of the effect of the treatment with the Phystrac traction device with carpal tunnel syndrome' and to provide an insight into possible factors which are of influence to the final effect and the duration of the treatment.

The questions which have been answered in this are divided into four different parts.

The effects are determined by means of the complaints score, the functional score and the muscle strength of the left and right hand. The complaints score and functional scores come from the Dutch version of the questionnaire: 'a self-administered Questionnaire for the Assessment of Severity of Symptoms and Functional Status in Carpal Tunnel syndrome' (Levine, 1993).

The first part of this research consists of the determination of the general effect of the treatment on the complaints score, the functional score and the muscle strength of the left and the right.

The second and third part, personal characteristics and physiotherapeutic research and anamnesis results address the question whether there are factors which have an influence on the effect of the treatment. Patients would like to know what the expectation of the treatments is. Through answering these questions, better expectations can be provided to the individual patient. The personal characteristics which are used are gender and age, the physiotherapeutic research and anamnesis results and having or not having had an EMG (Electromyography), the wearing or non-wearing of a brace, result of the Tinel and Phalen tests and the duration of the complaints.

The last part consists of the duration of the treatment (the number of treatments). Here, the influence of the number of treatments on the final effect of the treatments and at the influence of age and duration of complaints on the number of treatments has been observed. According to the information leaflet of the Phystrac traction treatments it is indicated that the duration of the treatment for milder cases of CTS is 10-12 treatments. In serious cases this would be more than 12 treatments. It is interesting to determine whether this corresponds with the experiences in Fysiotherapie Centrum Zuidwolde.

From the results of this research the conclusion can be drawn that the treatment

with the Phystrac traction device provides an improvement in the complaints score, the functional score and of the muscle strength of the left and the right. Therefore the treatment has an effect.

Regarding the factors which have an influence on the effect of the treatment the conclusion can be drawn that women have a greater improvement after the treatment regarding the complaints (pain, tingling, and suchlike) than men. Patients which, prior to the treatments, have a positive test of Phalen, have greater functional improvements (regarding activities) through the traction treatment than patients which have a negative test of Phalen prior to the treatment.

Furthermore, patients with less than a year of complaints prior to the treatment have the greatest improvement in the complaints (pain, tingling, and suchlike), patients with more than 5 years of complaints have the least improvement in the complaints through traction treatment.

The factors which have no influence on the effect of the treatment are age, an EMG or no EMG, wearing a brace or not, and the outcome of the Tinel test.

Regarding the duration of the treatment the conclusion can be drawn that the number of treatments has a large influence on the effect of the treatments. In patients with more than 12 treatments the greatest improvement in complaints (pain, tingling, and suchlike), and muscle strength of the left and the right is visible after the treatment, while patients who had less than 10 treatments have the least effect. From this it becomes clear that a minimum of 12 treatments is necessary to achieve the greatest effect.

Finally it becomes clear from this research that age and the duration of the existing complaints are not influential to the total number of treatments necessary. Thus, elderly people and young people need the same amount of treatments, just like people who have short-duration and long-duration complaints.

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Literature list

1. Introduction

1.1. Objective

1. The determination of the effect of the treatment with the Phystrac traction device with carpal tunnel syndrome on the complaints score, the functional score, and muscle strength.
2. Providing an insight into the possible factors which influence the final effect or the duration of the treatments.

1.2 Questioning

General questioning

Does the treatment of the carpal tunnel syndrome with the Phystrac traction device have an effect on the score and muscle strength on the left and on the right and what is the influence on this of gender, age, EMG, brace, the Tinel test, the Phalen test, the duration of the complaints and the number of treatments?

Constituent questions

General:

1. Does the treatment with the Phystrac traction device have an effect on the complaints relating to carpal tunnel syndrome on the complaints score, the functional score and the muscle strength on the left and on the right?

Personal characteristics

2. Is there a difference in the effect of the treatment with the Phystrac device between the various age-categories on the complaints score, the functional score and muscle strength?
3. Is there a difference in the effect of the treatment with the Phystrac traction device between men and women on the complaints score, the functional score and muscle strength?

Physiotherapeutic research and anamnesis results

4. Is there a difference in the effect of the treatment with the Phystrac traction device between people who have had an EMG or people who have not had an EMG prior to the series of treatments on the complaints score, the functional score and muscle strength?
5. Is there a difference in the effect of the treatment with the Phystrac traction device between people who wear a brace and people who do not wear a brace on the complaints score, the functional score and muscle strength?

6. Is there a difference in the effect of the treatment with the Phystrac traction device on the complaints score, the functional score and muscle strength between people who have had a positive Tinel test prior to the treatment with respect to people who have had a negative Tinel test?
7. Is there a difference in the effect of the treatment with the Phystrac traction device on the complaints score, the functional score and muscle strength between people who have had a positive Phalen test prior to the treatment with respect to people who have had a negative Phalen test?
8. Is there a difference in the effect of the treatment with the Phystrac traction device between the various categories 'duration of the existing complaints' on the complaints score, the functional score and muscle strength?

Number of treatments

9. Is there a difference in the effect of the treatment with the Phystrac traction device between the various categories 'number of treatments on the complaints score, the functional score and muscle strength?
10. Does age influence the total number of treatments with the Phystrac traction device in the event of CTS?
11. Does the duration of the complaints have an influence on the total number of treatments with the Phystrac traction device in the event of CTS?

2. Background questionnaire

In 1993 Levine et al. developed the American version of the questionnaire used in this research for carpal tunnel syndrome: a self-administered Questionnaire for the Assessment of Severity of Symptoms and Functional Status in Carpal Tunnel Syndrome'.

Until then the success of an operation of carpal tunnel syndrome was mainly measured by means of neuromuscular improvement and other physical measurements, while patients attach more value to the reduction of the symptoms and the improvement of functions. This was also measured, but with measurements which are not standardised, reliable, valid and sensitive to clinical changes. In addition to that these measurements were often carried out by the surgeon who had also carried out the operation, because of which an 'observer bias' could arise.

For this reason Levine set up a research to develop a scoring-instrument (questionnaire) for carpal tunnel syndrome with which the various complaints and functional problems can be evaluated and which is reliable, valid, internally consistent and sensitive to clinical changes.

During the drawing up of the questionnaire there was consultation with hand surgeons, rheumatologists and patients. On the basis of this 6 clear symptoms for the evaluation of the carpal tunnel syndrome have been identified: pain, tingling, deafness, reduction in strength, nocturnal symptoms and problems with functional skills in general.

These symptoms are laid down in the first part of the questionnaire, consisting of 11 questions, where the severity of these complaints can be indicated on a 5-point scale. 1 represents no complaints, 5 represents very severe complaints. This results in the complaints score, which is the average score of these 11 questions. Furthermore 12 functional activities have been laid down, which are often affected by CTS. After a pilot study 4 activities were removed (driving, typing, sport and working with tools). From the remaining 8 activities the second part of the questionnaire has arisen, the functional score. Here the patients can indicate on a 5-point scale to which extent they have a problem with the activity described in daily life. The functional score is also again an average score of the 8 items. If questions are not answered, they will not be calculated in the average score.

In this way a questionnaire was created in which complaints and functional problems of patients with carpal tunnel syndrome can be laid down. The developed scales transpired to be reliable (Pearson's correlation coefficient: $r = .91$ for the complaints score and $r = .93$ for the functional score), interim consistent (Cronback alpha .89 for the complaints score and .91 for the functional score) and sensitive for clinical changes (effect size complaints score: 1.4, functional score: 0.82).

In this research the Dutch version of the above described questionnaire will be used, taken over from research of Hoefnagel (1997) and from a pilot study of TIGRA Utrecht. Whether the Dutch translation is also valid and reliable is not indicated in either areas of the research.

3. Method

3.1 The measuring instrument

The questionnaire which is used for the measuring of the complaints score and functional score is the Dutch translation of the 'questionnaire for the Assessment of Severity of Symptoms and Functional Status in Carpal Tunnel Syndrome (Levine, 1993).

A number of general questions regarding personal data, the physiotherapeutic examination, and differential diagnostics are added to this questionnaire. The questionnaires regarding the complaints score and the functional score are always held prior to the series of treatment and usually towards the end of the series of treatment.

Furthermore the muscle strength of both hands is determined with a pinchgrip dynamometer before each treatment.

3.2 The research population

The research population consists of all patients who, over the past year, have been treated with the Phystrac traction device for carpal tunnel syndrome at Fysiotherapie Centrum Zuidwolde NL , Where the questionnaires have been conducted and the strength measurements have been made.

3.3 Analysing the data

3.3.1 Processing the data

The calculations of differences between the before and after series of treatments are carried out with the complaints score, the functional score, and the muscle strength on the left and on the right.

The complaints score is calculated by taking the average of the first 11 questions on the questionnaire, the functional score is calculated by taking the average of the last 8 questions (or less, if these were not completed).

Both categories consist of a 5-point scale, where 1 point is scored when there are no problems, and 5 points in the event of very severe problems.

The muscle strength prior to the series of treatment is determined by taking the average of the first 3 measurements, because the first measurement often seems too low.

The muscle strength after the series of treatment is determined by taking the average of the last three measurements. This is because the muscle strength according to the patients themselves is very dependent on the time of the day, and often the patients were not treated at set times.

3.3.2

Static processing of the data.

In order to be able to demonstrate the effects and differences between the effects with various groups, statistical analysis methods have been used in the statistics programme SPSS 13.0 (Huizingh, 2005).

The dependent variables in this research are the complaints score, the functional score, the muscle strength on the left and the muscle strength on the right. The independent variables are age, gender, EMG, brace, the Phalen test, the Tinel test, the duration of the complaints and the number of treatments.

These variables are dependent on the questions and entered into the variance analysis per independent variable for repeated measures (GLM repeated measures), which is used for a spot-check with paired observation. This measures possible differences in average test scores at two or more measuring periods. The GLM repeated measures is an analysis which can be used when the dependent variables have group averages of at least interval measurement level. Another condition for this analysis is that the group averages are divided normally and that the variances in different groups are equal. Furthermore, in the GLM analysis we speak of a significant difference when the chance that the difference found resulting from a coincidence is less than 5%.

The reason that all results are not processed in 1 analysis but are entered per question is that the majority of the questionnaires are not filled in completely. This way more results of the testees can be used and the analysis will not be limited only to those testees who have entirely completed the questionnaires (this is 10 out of 78!).

With the processing of the results there is always an indication of how many testees are involved in the analysis.

The results will be discussed per main effect and interaction effect. Only the interaction effects which are important for the answering of the questions will be discussed.

Finally the influence of age and the duration of the complaints on the number or treatments will still be carried out with a univariate GLM analysis for the answering of the last two questions. With the 'test of between subjects factor' the main effects of age and duration of the complaints on the number of treatments can be read.

4. Results

4.1 Characteristics of the research population

Number of testees

A total of 86 testees participated in this research, where in the end the data of 78 has been used. A number of testees have been left out because they have stopped after the intake or the 1st treatment. The data will be processed, as

discussed in the method, per question per independent variable, which is why for each analysis a different number of testees are included. In the analysis it is stated how many testees are involved.

Age

The average age of the 78 testees is 54.38 year (SD = 13.42 years), the mean lies at 56 years. The youngest testee was 25 years of age, the oldest 86. In the table below the age division is indicated (such as is classified in the age categories with the analysis).

Age	N	%
< 40 years	13	16.7
40-60 years	42	53.8
>60 years	23	29.5
Total	78	100

Problem hand, number of injections, operation.

Of the 78 testees, 54 had complaints on both hands (=69.2%), 10 on the left (12.7%) and 14 on the right (17.9%).

15 of these testees had had 1 or several injections (19.2%), the remaining 63 did not (80.8%).

In total 22 testees had undergone an operation prior to the treatment (28.2%). On average this was 7 months before (SD 2.16 year).

Of the 22 testees who had undergone an operation, there were three that had had an operation on both hands (3.8%), 10 only on the left (12.8%) and 9 only on the right (11.5%).

The remaining 56 testees had not undergone an operation.

Number of years of the complaints

On average the testees have had complaints for 4 years and 1 month at the moment they come for the traction treatment (SD 5.22). The mean lies on 2 years of complaints until the intake. The minimum duration of complaints up to the moment of intake within the group of 78 testees is 1 month, while the maximum of this is 25 years of complaints. In the diagram below the duration of the complaints is summarized as a group.

Duration of the complaints	N	%
< 1 year	30	38.5
1-5 years	33	42.3
> 5 years	15	19.2
Total	78	100

Outcome of physiotherapeutic research

In the table below the results of the physiotherapeutic research of the 78 testees are summarized.

The VAS pain scale is only taken prior to the treatment with 40 testees. The average score of this is 5.8 (SD=2.8), with the mean at 6.0.

Table 1: Result of the physiotherapeutic research

Test		N	%
TOCS (Test of Roos)	Positive	3	3.8
	Negative	25	31.6
	Not tested	51	64.4
Cervica(discogene)problems	Positive	9	11.4
	Negative	21	26.6
	Not tested	49	62.0
Pronator teres syndrome	Positive	0	0
	Negative	25	31.6
	Not tested	54	68.4
Atrophy m. opponens pollicis	Positive	3	3.8
	Negative	25	31.6
	Not tested	51	63.3
The Tinel test	Positive	12	15.2
	Negative	18	22.8
	Not tested	48	62.0
The Phalen test	Positive	19	24.1
	Negative	10	12.7
	Not tested	49	36.2

Total number of treatments, traction strength and advancement

On average, the traction force used in the first treatment is 4 kg, with a minimum of 2 kg and a maximum of 6 kg. The final traction force that was achieved was 8kg on average with a minimum of 2 kg and a maximum of 10 kg. The number of treatments undergone to reach this traction force is 5 (minimum 1 treatment, maximum 18).

The total number of treatments undergone on average by 78 testees is 13.12 (SD 5.35); mean at 14. The minimum number of treatments is 2, maximum 34. In the diagram below the number of treatments is presented as a group, such as will be used in the analyses.

Total number of treatments	N	%
< 10	24	30.8
1- 12	9	11.5
> 12	45	57.7
Total	78	100

Index numbers on the average complaint and functional scores, and muscle strength.

In the tables 2 and 3 the averages and standard deviations on the complaints score, the functional score and the muscle strength on the left and on the right are indicated. (The blue coloured sections illustrate significant differences; this will be discussed with the interaction – effects).

Table 2: averages and standard deviations on the complaints score and the functional score

		Complaints score					Functional score				
		Before		After		N	Before		After		N
		Aver	SD	Aver	SD		Aver	SD	Aver	SD	
EMG	Yes	2.90	.71	1.58	.61	35	2.61	.98	1.74	.87	20
	No	2.76	.67	1.57	.52	18	2.49	.93	1.55	.60	12
	Total	2.85	.70	1.58	.57	53	2.57	.96	1.67	.78	32
Brace	Yes	2.80	.70	1.85	.90	12	2.52	1.13	1.88	1.02	6
	Nee	2.86	.70	1.50	.42	42	2.52	.97	1.60	.72	27
	Total	2.85	.69	1.57	.57	54	2.52	.98	1.65	.77	33
Gender	Man	2.56	.84	1.77	.74	7	1.83	.50	1.50	.50	5
	Woman	2.89	.66	1.54	.54	47	2.64	.99	1.67	.82	28
	Total	2.84	.69	1.57	.57	54	2.52	.98	1.65	.77	33
Age	<40	2.99	.61	1.78	.94	9	3.03	.81	1.90	1.08	5
	40-60	2.89	.69	1.50	.50	33	2.48	1.06	1.58	.76	21
	>60	2.61	.74	1.60	.35	12	2.27	.79	1.69	.64	7
	Total	2.85	.69	1.57	.57	54	2.52	.98	1.65	.77	33
Tinel	Pos.	3.26	.42	1.59	.46	9	2.75	.66	1.63	.22	3
	Neg.	2.55	.65	1.54	.63	12	2.20	.72	1.57	.61	7
	Total	2.85	.66	1.56	.55	21	2.36	.71	1.59	.51	10
Phalen	Pos.	3.00	.63	1.54	.49	14	2.73	.66	1.56	.57	6
	Neg.	2.56	.65	1.60	.69	7	1.81	.39	1.62	.49	4
	Total	2.85	.66	1.56	.55	21	2.36	.72	1.59	.51	10
Duration of complaints	< 1	3.04	.67	1.44	.31	21	2.53	1.02	1.34	.46	10
	1-5	2.82	.70	1.67	.77	23	2.66	1.02	1.93	.96	15
	> 5	2.50	.62	1.62	.44	10	2.25	.90	1.53	.56	8
	Total	2.85	.69	1.57	.57	54	2.52	.98	1.65	.77	33
Number of treatments	<10	2.66	.74	1.84	1.06	9	2.40	.98	1.98	1.01	6
	10-12	2.61	.51	1.57	.43	8	2.57	1.05	1.63	.63	4
	>12	2.94	.70	1.50	.41	37	2.55	1.00	1.57	.74	23
	Total	2.85	.69	1.57	.57	54	2.52	.98	1.65	.77	33

Table 3: averages and standard deviations on the muscle strength on the left and on the right

		Muscle strength left					Muscle strength right				
		Before		After		N	Before		After		N
		Aver	SD	Aver	SD		Aver	SD	Aver	SD	
EMG	Yes	23.04	8.82	27.45	8.90	47	23.15	9.21	27.34	9.17	47
	No	26.54	7.64	29.04	8.67	24	25.70	8.52	28.17	10.09	23
	Total	24.23	8.55	27.99	8.80	71	23.99	9.01	27.61	9.42	70
Brace	Yes	21.23	9.90	23.46	9.65	13	20.77	10.08	23.77	9.51	13
	No	25.45	8.62	29.48	8.74	58	25.04	8.89	28.88	9.40	57
	Total	24.68	8.94	28.38	9.15	71	24.24	9.20	27.93	9.56	70
Gender	Man	37.29	10.78	40.29	9.74	7	33.29	10.99	38.86	12.36	7
	Woman	23.23	7.57	26.98	8.05	66	23.20	8.37	26.62	8.38	65
	Total	24.58	8.90	28.26	9.05	73	24.18	9.08	27.81	9.46	72
Age	<40	25.83	11.49	30.33	11.50	12	24.82	11.31	30.18	12.00	11
	40-60	25.21	8.23	29.51	7.43	39	25.13	8.17	29.18	7.90	39
	>60	22.62	8.69	24.62	9.87	21	21.62	9.39	23.76	10.10	21
	Total	24.56	8.94	28.22	9.11	72	24.04	9.07	27.73	9.51	71
Tinel	Pos.	25.73	6.64	29.73	7.34	11	26.18	7.69	30.55	9.30	11
	Neg.	27.94	6.30	30.18	6.92	17	26.65	8.82	29.06	8.44	17
	Total	27.01	6.41	30.00	6.96	28	26.46	8.25	29.64	8.65	28
Phalen	Pos.	25.61	6.61	29.17	7.15	18	26.94	7.86	30.00	8.77	18
	Neg.	29.70	5.36	31.50	6.69	10	25.60	9.29	29.00	8.87	10
	Total	27.07	6.41	30.00	6.96	28	26.46	8.25	29.64	8.65	28
Duration of complaint	< 1	23.00	8.22	27.07	9.03	27	24.26	8.92	27.41	10.11	27
	1-5	24.16	9.76	28.39	9.11	31	21.81	9.16	26.58	8.81	31
	> 5	28.43	7.72	30.43	9.54	14	29.85	7.46	31.69	9.67	13
	Total	24.56	8.94	28.29	9.11	72	24.21	9.14	27.83	9.53	71
Number of treatment	<10	24.00	9.70	25.10	10.56	21	23.21	10.56	24.32	11.80	19
	10-12	23.75	4.33	28.50	4.75	8	23.63	6.12	27.25	7.56	8
	>12	24.98	9.31	29.81	8.72	43	24.75	9.08	29.45	8.49	44
	Total	24.56	8.94	28.29	9.11	72	24.21	9.14	27.83	9.53	71

4.2 Reasons to stop

With 18 testees the treatment was ended prematurely. Below, the reasons for this are described and possible side pathologies of these patients.

No effect

There were 9 testees where the treatments had no effect. 4 Of these testees had a side pathology, these were successively: wrist fracture '99, extensive image, no clear CTS, MRI **LSWK**: strong rotation LWK (lumbar vertebral column) and left shoulder **PHS**, RA.

Increase in the complaints

With 3 patients there was a clear increase in the complaints. With 2 of these patients no clear CTS was determined in advance, one of them had DM in addition to that and the other one a whiplash. With the 3rd testee no cause could be found for the increase in complaints.

Furthermore there were 2 testees where 1 hand responded well to the treatment whereas the other did not respond well. 1 of these persons had hyperaesthesia in the hand that did not respond well to the treatment, which did, in fact, diminish a little. The other person got stabs of pain in the hand which did not respond well. This person had DM as a side pathology.

Changing, moment dependent worsened complaints

2 testees found the effect of the treatment varied a lot, depending on the moment the complaints worsened or diminished a lot. Both persons had a side pathology; namely psoriatic rheumatism and fibromyalgia. In consultation both persons stopped the treatment prematurely.

Other

1 testee ended the treatment prematurely because the complaints were gone after giving birth. Another testee had an EMG examination in the course of the series of treatment which was negative, so no CTS. Therefore that treatment was terminated. 2 patients felt, despite the complaints not having disappeared, that the treatment could be stopped first to await further developments.

DM, RA, fibromyalgia, arthrosis

The above disorders can be a reason to stop the treatment. In earlier researches some of these disorders were also excluded from the research (Hoefnagel 1997, the TIGRA Utrecht research).

In this research no exclusion criteria have been used; it is therefore interesting to see whether there are also testees with this side pathology which have benefited from the treatment. Below, the side pathologies are stated with the number of testees which completed the treatment with a positive result:

- Psoriatic rheumatism: 1
- Arthrosis (in the fingers) 1
- fibromyalgia 3
- DM 1

So in this research the group testees with the side pathologies DM and a type of rheumatism who had not terminated the treatment were greater than those who did end the treatment.

4.3 The effect

For the processing of the data, the GLM repeated measures were used after it transpired that the conditions for the use of the GLM were met; the dependent variables are divided normally and there are equal variances in the groups. The results of these analyses are described below.

4.3.1 Main effects

In table 4 the results are described of the analyses of the main effects on the complaints score, the functional score and the muscle strength on the left and on the right after the treatment with respect to before the treatment. From this it becomes clear that all 4 main effects are significant.

Therefore there is a difference between before and after the series of treatment with all 4 variables. In order to determine the direction of this difference, table 5 has been added, with the averages of the scores of before and after the series of treatment.

In this it shows that the average complaints score (before: 2.85 and after: 1.57) and the functional score (for 2.52 and 1.65) diminished after the series of treatment with respect to before the series of treatment. The average muscle strength on the left (before: 24.58N and after: 28.26N) and on the right (before: 24.18N and after: 27.81N) increased after the treatments relative to before the treatments.

Table 4: The main effects with regard to the questionnaire scores and muscle strength

Effect	Wilks'7	F-value	df	Error df	p-value
Complaints score	.238	169.713	1	53	.00 ^a
Functional score	.580	44.204	1	32	.00 ^a
Muscle strength on the left	.397	47.398	1	72	.00 ^a
Muscle strength on the right	.652	37.848	1	71	.00 ^a

^a Significant with $\alpha = .05$

Table 5: The average scores on the questionnaires and the average muscle strength.

	Before		After		N
	Aver.	SD	Aver.	SD	
Complaints score	2.85	.69	1.57	.57	54
Functional score	2.52	.98	1.65	.77	33
Muscle strength on the left	24.58	8.88	28.26	9.05	73
Muscle strength on the right	24.18	9.08	27.81	9.46	72

4.3.2 Interaction effects

Gender

Table 6: The interaction effects with regard to the questionnaires scores and muscle strength and the gender

Effect	Wilks'7	F-value	df	Error df	p-value
Complaints score	.929	.3956	1	52	.05 ^a
Functional score	.904	3.305	1	31	.08
Muscle strength on the left	.998	.172	1	71	.68
Muscle strength on the right	.983	1.178	1	70	.28

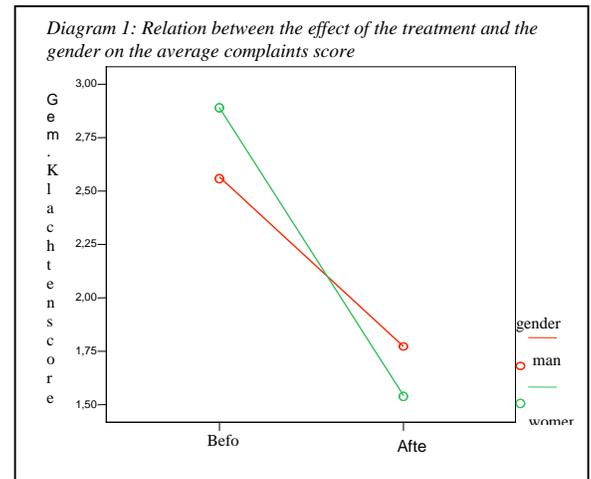
Significant with $\alpha = .05$

The table above illustrates that there is no significant interaction effect between gender and the effect of the treatment ($p=.05$, $F=.3956$). The direction of this effect is illustrated in the diagram and table below. From this it transpires that the effect of the treatment on the average complaints score is greater with women (1.35) than with men (0.79).

For the functional score ($p=.08$, $F=3.305$), muscle strength on the left ($p=.68$, $F=.172$) and muscle strength on the right ($p=.28$, $F= 1.178$) no significant effects have been found between the genders and the effect of the treatment.

Diagram 1: Relation between the effect of the treatment and The gender on the average complaints score

Gender	Before		After		Effect Aver.	47
	Aver.	SD	Aver.	SD		
Man	2.56		1.77	.74	0.79	
Women	2.89	.66	1.54	.54	1.35	



Gender	Before		After		Effect Aver.	47
	Aver.	SD	Aver.	SD		
Man	2.56		1.77	.74	0.79	
Women	2.89	.66	1.54	.54	1.35	

Age

Table 7: The interaction effects with regard to the questionnaire scores and muscle strength and age

Effect	Wilks' η^2	F-value	df	Error df	p-value
complaints score	.950	1.33	2	51	.27
Functional score	.946	.856	2	30	.44
Muscle strength on the left	.945	2.007	2	69	.14
Muscle strength on the right	.951	1.757	2	68	.18

From the table above it transpires that there are no significant interaction effects between the different age groups and the effect of the series of treatment (complaints score $p=0.08$, $F=1.33$; functional score $p=.44$, $F=.856$; muscle strength on the left $p=.14$, $F=2.007$; muscle strength on the right $p=.18$, $F=1.757$).

EMG

Table 8: The interaction effects with regard to the questionnaire scores and muscle strength and EMG

Effect	Wilks' η^2	F-value	df	Error df	p-value
Complaints score	.993	.385	1	51	.55
Functional score	.998	.061	1	30	.81
Muscle strength on the left	.961	2.777	1	69	.10
Muscle strength on the right	.974	1.783	1	68	.19

The table above illustrates that there are no significant interaction effects between having had an EMG or not and the effect of the series of treatment (complaints score $p=.55$, $F=.385$; functional score $p=.81$, $F=.061$; muscle strength on the left $p=.10$, $F=2.777$; muscle strength on the right $p=.19$, $F=1.783$).

Brace

Table 9: The interaction effects with regard to the questionnaire scores and muscle strength and brace

Effect	Wilks'7	F-value	df	Error df	p-value
Complaints score	.942	3.179	1	52	.08
Functional score	.980	.627	1	31	.43
Muscle strength on the left	.977	1.642	1	69	.20
Muscle strength on the right	.996	.292	1	68	.59

The table above illustrates that there are no significant interaction effects between wearing a brace or not and the effect of the series of treatments (complaints score $p=.08$, $F=.3.179$; functional score $p=.43$, $F=.627$; muscle strength on the left $p=.20$, $F=1.642$; muscle strength on the right $p=.59$, $F=.292$).

Tinel

Table 10: The interaction effects with regard to the questionnaire scores and muscle strength and the Tinel test

Effect	Wilks'7	F-value	df	Error df	p-value
Complaints score	.881	2.435	1	18	.14
Functional score	.986	.098	1	7	.76
Muscle strength on the left	.991	.233	1	25	.63
Muscle strength on the right	.937	1.683	1	25	.21

The table above illustrates that there are no significant interaction effects between the result of the Tinel test and the effect of the series of treatment (complaints score $p=.14$, $F=.2.435$; functional score $p=.76$, $F=.098$; muscle strength on the left $p=.63$, $F=.233$; muscle strength on the right $p=.21$, $F=1.683$).

Phalen

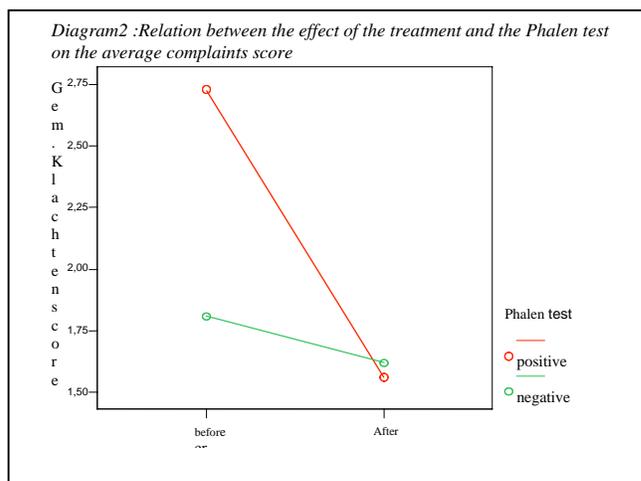
Table 11: The interaction effects with regard to the questionnaire scores and muscle strength and the Phalen test

Effect	Wilks' η^2	F-value	Df	Error df	p-value
Complaints score	.994	.112	1	18	.74
Functional score	.302	16.183	1	7	.001 ^a
Muscle strength on the left	.992	.192	1	25	.67
Muscle strength on the right	.968	.825	1	25	.37

Significant with $\alpha = .05$

For the functional score a significant interaction effect has been found ($p=.011$, $F=16.183$) between the result of the Phalen test and the effect of the treatment. In the diagram and table below the direction of this interaction effect is visible. From this it transpires that the effect of the treatment is greater with patients with a positive Phalen test (1.17) than a negative Phalen test (0.19) prior to the treatment. With regard to the complaints score ($p=.74$, $F=.994$), the muscle strength on the left ($p=.67$, $F=.192$) and the muscle strength on the right ($p=.37$, $F=.825$) there are no significant interaction effects between the result from the Phalen test and the effect of the treatment, which transpires from table 11.

Diagram 2: Relation between the effect of the treatment and the Phalen test on the average complaints score



Phalen test	before		after		effect	
	Aver.	SD	Aver.	SD	Aver.	N
Positive	2.73	.66	1.56	.57	1.17	6
Negative	1.81	.39	1.62	.49	0.19	4

Duration of the complaints

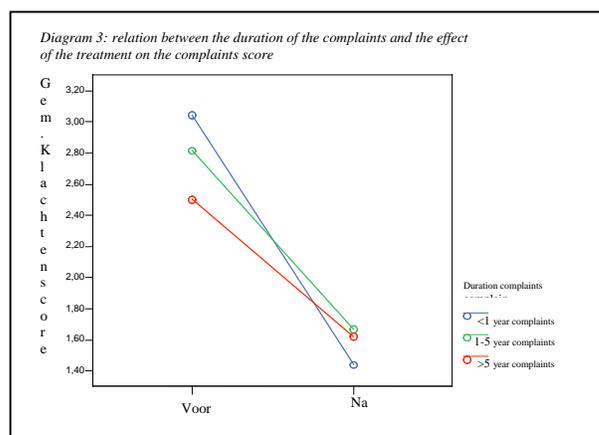
Table 12: The interaction effects with regard to the questionnaire scores and muscle strength and the duration of the complaints

Effect	Wilks' η^2	F-value	df	Error df	p-value
Complaints score	.848	4.559	2	51	.02 ^a
Functional score	.919	1.328	2	30	.28
Muscle strength on the left	.965	1.264	2	69	.29
Muscle strength on the right	.950	1.778	2	68	.18

Significant with $\alpha = .05$

Table 12 illustrates that there are no significant interaction effects between the duration of the complaints and the effect of the treatment on the functional score ($p=.28$, $F=1.328$), muscle strength on the left ($p=.29$, $F=1.264$) and the muscle strength on the right ($p=.18$, $F=1.778$). However, there is a significant interaction effect between the duration of the complaints and the effect of the treatment on the complaints score ($p=.02$, $F=4.559$). The direction of this effect is illustrated in the diagram 3 and the table below. There is a greater effect of the treatment in patients who have complaints for less than 1 year (1.60), than for patients who have complaints for 1-5 years (1.15) and the smallest effect can be found in patients which have had complaints for more than 5 years (0.88).

Diagram 3 : Relation between the duration of the complaints and the effect of the treatment on the complaint score



	before		after		effect	
Complaints	Aver.	SD	Aver.	SD	Aver.	N
< 1 year	3.04	.67	1.44	.31	1.60	21
1-5 year	2.82	.70	1.67	.77	1.15	23
> 5 year	2.50	.62	1.62	.44	0.88	10

Number of treatments

Table 13: The interaction effects with regard to the questionnaire scores and muscle strength and the number of treatments

Effect	Wilks' η^2	F-value	df	Error df	p-value
Complaints score	.877	3.593	2	51	.04 ^a
Functional score	.917	1.355	2	30	.27
Muscle strength on the left	.861	5.552	2	69	.01 ^a
Muscle strength on the right	.903	3.647	2	68	.03 ^a

Significant with $\alpha = .05$

With regard to the number of treatments the table illustrates that there only is no significant interaction effect between the number of treatments and the functional score ($p=.27$, $F=1.335$). For the complaints score ($p=.04$, $F=.877$), muscle strength on the left ($p=.01$, $F=.861$) and the muscle strength on the right ($p=.03$, $F=3.647$) there are however significant interaction effects between the number of treatments and the effect of the treatment. In diagram 4, 5 and 6 with the corresponding tables the directions of these effects are illustrated. From this it transpires that the effect of the treatment on the complaints score is the greatest for patients who have had more than 12 treatments (1.44 and the smallest for patients who have had less than 10 treatments (0.82).

The increase in strength of the left (4.83 with respect to 1.10) and the right hand (4.70 with respect to 1.11) are also the greatest with more than 12 treatments and the smallest with less than 10 treatments.

Treatments	Before		After		Effect	
	Aver.	SD	Aver.	SD	Gem	N
< 10	2.66	.74	1.84	1.06	0.82	9
10-12	2.61	.51	1.57	.43	1.04	8
> 12	2.94	.70	1.50	.41	1.44	37

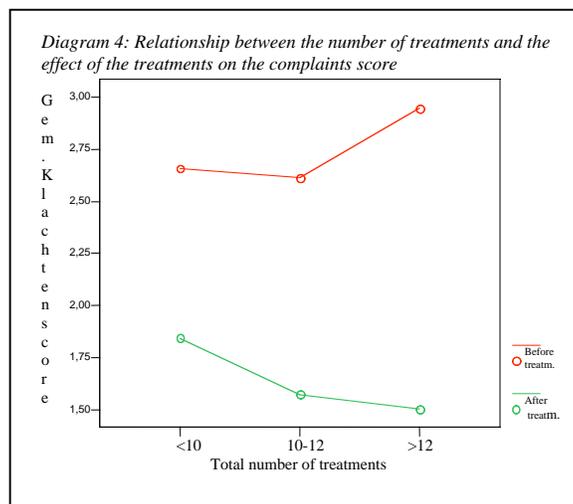


Diagram 5: Relation between the number of treatments and the effect of the treatments on muscle strength on the left

Number treatments	Before		After		Effect	
	Aver.	SD	Aver.	SD	Aver.	N
< 10	24.00	9.70	25.10	10.56	1.10	21
10-12	23.75	4.33	28.50	4.75	4.75	8
> 12	24.98	9.31	29.81	8.72	4.83	43

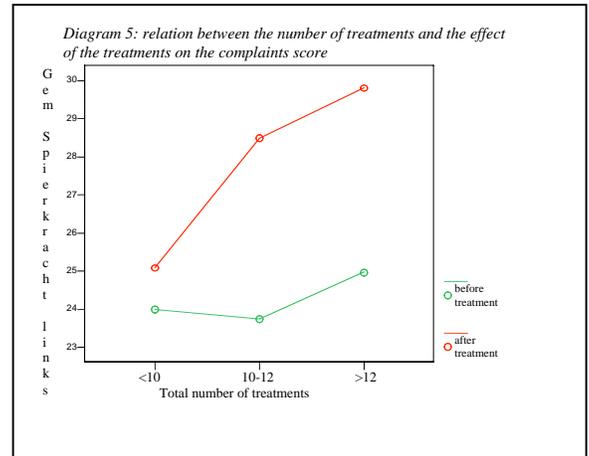
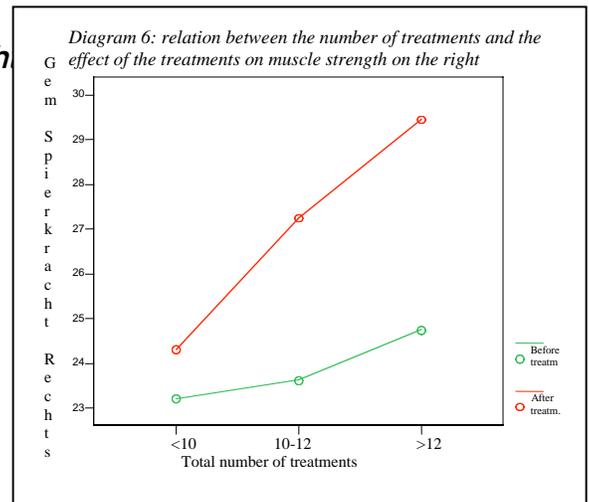


Diagram 6: Relation between the number of treatments and the effect of the treatments on muscle strength on the right

Number treatments	Before		After		Effect	
	Aver.	SD	Aver.	SD	Aver.	N
< 10	23.21	10.56	24.32	11.80	1.11	19
10-12	23.63	6.12	27.25	7.56	3.62	8
> 12	24.75	9.08	29.45	8.49	4.70	44



The influence of the age and gender on the number of treatments

As described in the methods, these effects are determined by means of a different analysis than used before: a univariate analysis (GLM univariate). The conditions for normal division and equal variances for the 'number of treatments' have been complied with.

Table 14: the main effects for age and the duration of complaints on the number of treatments

	Sum of Squares	F-value	df	p-value
Age	5.33	.149	1	.70
Duration of complaints	1.47	.110	1	.74

Table 14 illustrates that there are no significant effects for age ($p = .70$; $F = .149$) and the duration of the complaints ($p = .74$; $F = .110$).

5. Conclusions and discussions

General

Question 1: Does the treatment with the Phystrac traction device have an effect on the complaints relating to carpal tunnel syndrome on the complaints score, the functional score and the muscle strength on the left and on the right?

To answer this question we take a look at the main effects of the complaints score, the functional score and the muscle strength on the left and on the right. From this it transpires that the complaints score and the functional score are higher before the series of treatments than after, and the muscle strength on the left and right are higher after the series of treatment than before.

This means that the complaints score and the functional score have improved as a result of the series of treatment. So the testees have fewer complaints (pain, tingling, and suchlike) and fewer problems with functional activities after the treatment with the Phystrac traction device.

Furthermore the muscle strength on the left and/or the right hand increases after the series of treatment. So the testees have more strength as a result of the treatment with the Phystrac traction device.

Therefore, the treatment with the Phystrac traction device with the carpal tunnel syndrome has an effect on the reduction in the complaints, the improvement of the functional activities and the improvement of the muscle strength.

Personal characteristics

Question 2: Is there a difference in the effect of the treatment with the Phystrac traction device between various age categories on the complaints score, the functional score and the muscle strength?

From the interaction effect for age it transpires that there are no differences in the effect of the treatment between the three age categories. Therefore, the effect of the treatment with the Phystrac traction device is not different for people in the age category younger than 40, between 40-60, and older than 60.

Question 3: Is there a difference in the effect of the treatment with the Phystrac traction device between men and women on the complaints score, the functional score and the muscle strength? With the interaction effect of the gender we see that women have a greater effect of the treatment on the complaints score than men. Therefore women have a greater improvement of complaints (pain, tingling, and such) after the treatments than men.

The complaints score is a subjective score, thus the greater effect of the treatment found in women rather than in men does not mean that the effect of

the treatment in women is actually greater, only that women experience the effect as greater.

For the functional score and the muscle strength on the left and right no differences have been found in the effect of the treatment between men and the women.

With these results between men and women we have to comment that the group of men in the research was a lot smaller than the group of women, which can influence the results.

Physiotherapeutic research and anamnesis results

Question 4: Is there a difference in the effect of the treatment with the Phystrac traction device between people who have and people who have not had an EMG prior to the series of treatments on the complaints score, the functional score and the muscle strength?

When we look at the interaction effect of EMG, then no differences have been found in the effect of the series of treatments between testees who have had an EMG and those who have not had an EMG prior to the series of treatments on the complaints score, the functional score and the muscle strength on the left and right.

On the basis of having had an EMG or not, it is not possible to formulate various expectations of the series of treatments prior to the treatment.

Question 5: Is there a difference in the effect of the treatment with the Phystrac traction device between people who wear a brace and people who do not wear a brace on the complaints score, the functional score and the muscle strength?

In order to be able to answer this question we must look at the interaction effect of 'brace'. From this it becomes clear that there is no difference between those who are or are not wearing a brace on the effect of the treatment on the complaints score, the functional score and muscle strength on the left and right. Wearing a brace or not is therefore has no influence on the effect of the treatment.

So on the basis of wearing a brace or not, no different expectations of the series of treatment can be expected prior to the treatment.

A comment with these results is that the size of the group of the testees who do wear a brace is a lot smaller than the size of the group of testees who do not wear a brace.

This could influence the results.

Question 6: Is there a difference in the effect of the treatment with the Phystrac traction device on the complaints score, the functional score and the muscle strength between people who have had a positive Tinel test prior to the treatment with respect to people who have had a negative Tinel test?

For the interaction effect of 'Tinel', no differences have been found in the effect between testees with a positive and a negative Tinel test prior to the treatment. A positive Tinel test prior to the treatment therefore does not mean that the effect of the treatment will be different than with someone with a negative Tinel test prior to the treatment.

On the basis of the Tinel test it is therefore not possible to formulate various expectations regarding the effect of the treatment. The expectation of the effect of the series of treatments is equal for a positive and negative result of the Tinel test prior to the treatment.

Question 7: Is there a difference in the effect of the treatment with the Phystrac traction device on the complaints score, the functional score and the muscle strength between people who have had a positive Phalen test prior to the treatment with respect to people who have had a negative Phalen test?

In order to formulate an answer to this question we must look at the interaction effect of 'Phalen'. From this it transpires that testees with a positive Phalen test experience a greater effect of the treatment on the functional score than testees with a negative Phalen test prior to the treatment. From the diagram it becomes clear that this difference is particularly caused by the fact that testees with a positive Phalen test prior to the treatment have more functional problems. After the treatment they score more or less the same on the functional score as testees with a negative Phalen test prior to the treatment.

On the basis of a positive Phalen test it is therefore possible to expect that the effect of the series of treatments will be greater on the functional score than with a negative Phalen test prior to the treatment.

With regard to the complaints score and muscle strength on the left and right no differences have been found in the effect of the treatment between a positive and a negative Phalen test. On the basis of this it can therefore be expected that people with a positive and negative Phalen test prior to the treatment will experience the same effect from the treatment.

With these results it must be taken into account that the research groups are very small, as a result of which the statistical power of these results is also small.

Question 8: Is there a difference in the effect of the treatment with the Phystrac traction device between the different categories 'duration of the existing complaints' on the complaints score, the functional score and the muscle strength?

When we look at the interaction effect of 'duration of the complaints' it transpires that the testees with less than 1 year of complaints have the greatest effect from the series of treatment on the complaints score, testees with more than 5 years of complaints have the least effect on this. Whether this difference occurs because of an actual difference in complaints, or by a difference in experienced complaints, cannot be determined. The complaints score is a subjective score; it can therefore be that the testees who have had more than 5 years of complaints

prior to the series of treatments experience the existing complaints as less severe than testees with less than 1 year of complaints. It can also be the case that complaints that exist for more than 5 years can be treated less well with the help of the Phystrac traction device.

For the functional score and muscle strength on the left and right no differences have been found in the effect of the series of treatments between testees who have had complaints for less than 1 year, those who have 1-5 years of complaints and those who have more than 5 years of complaints.

On the basis of the duration of the existing complaints prior to the series of treatments it can therefore be expected that testees with whom the complaints exist for less than 1 year have the greatest effect of the treatment on the complaints score and testees with more than 5 years of complaints the smallest effect. On the functional score and the muscle strength on the left and the muscle strength on the right, no differences can be expected on the basis of the duration of the existing complaints.

Number of treatments

Question 9: Is there a difference in the effect of the treatment with the Phystrac traction device between the different categories 'number of treatments' on the complaints score, the functional score and the muscle strength?

For the interaction effect of 'number of treatments' it applies that only for the functional score have no differences been found in the effect of the series of treatments between the groups of less than 10 treatments, 10-12 treatments and more than 12 treatments.

For the complaints score it applies that the testees with more than 12 treatments have the greatest effect from the treatment and testees with less than 10 treatments the smallest effect.

With regard to the muscle strength on the left and right the same applies; the muscle strength has increased most with the testees with more than 12 treatments, and the least with testees with less than 10 treatments.

In the information leaflet about the treatment with the Phystrac traction device it is indicated that 10-12 treatments are needed for the milder cases of CTS and more treatments for the more severe cases. Therefore it shows from the results of this research that the greatest effects of the series of treatments can be found with more than 12 treatments. Thus, according to the leaflet this should concern the more serious cases. These patients should then, prior to the treatment, have a higher complaints score and less muscle strength. In diagram 4, 5 and 6 is illustrated that the complaints score with patients with more than 12 treatments lies, however, a little higher, but the muscle strength prior to the treatment is also higher. This therefore does not clearly point towards the more severe cases. From this research it becomes clear that more than 12 treatments produces a greater effect for all patients, not only for the more severe cases.

Question 10: Does age have an influence on the total number of treatments with the Phystrac traction device with CTS?

From the main effect of age on the total number of treatments it becomes clear that there is no difference in the average number of treatments for the age groups younger than 40, 40-60 and older than 60 year. Therefore, all age groups need the same number of treatments on average, so age does not influence the total number of necessary treatments.

Question 11: Does the duration of the complaints have an influence on the total number of treatments with the Phystrac traction device with CTS?

With the main effect for the duration of the complaints on the total number of treatments we can see that there are no differences between the testees with less than 1 year, 1-5 years or more than 5 years of complaints on the average number of necessary treatments.

The three groups therefore, on average, all need the same number of treatments, so the duration of the complaints does not influence the total number of necessary complaints.

6. Shortcomings of the research

The questionnaires have been conducted consistently before the start of the series of treatments, but the second time the questionnaires were conducted, they were often conducted somewhere towards the end of the treatment for evaluation, in order to determine whether the treatment must be continued or not. For results such as indicated in the research as after the treatment, in most cases these therefore are not actually conducted at the end of the series of treatment and have not strictly been outlined in the same measuring periods.

Especially with the interaction effects, the proportions between the sizes of groups are sometimes very distorted. The GLM repeated measurements do correct this to a certain extent, but it would be better if the sizes of groups were more equal.

The strength measurements seem very moment dependent. Now the strength has often been measured with the same testee at various times of the day, because of which differences in strength occur. That is why a choice has been made for an average strength of the 1st 3 and the last 3 treatments. This could give a distorted picture.

7. Recommendations for further research

- Questionnaires to be conducted, in any case, before and after the series of treatments. Possibly interim for evaluation, but for this it is then necessary

always to use a fixed measurement point. Noting all measurement points on 1 form is the most practical for the entering of the data.

- Always clearly note all data so that the research groups for all data can be as large as possible. Such as testing the outcomes of the CTS, preference hand, VAS (before and after the treatment!) side pathology, after how many treatments the use of the brace was stopped.
- Plan patients as much as possible at fixed times regarding the measurement of the strength. However, measure the strength consistently with each treatment, because a trend can then become clear and it will be easier to choose, for example, an average strength at the beginning and end of the treatment, with the processing of the results. Measurements which deviate a lot will then also stand out more.
- Lay down inclusion and exclusion criteria in order to create as homogenous as possible a research population. For this it is important to lay down the side pathologies and suchlike as well as possible. (Inclusion criteria, for example results EMG, exclusion for example a broken wrist or an operation on the wrist in the past, DM, pregnancy, RA, arthrosis, cervical images).
- Should the treatment be terminated prematurely, then note the reasons very clearly, in order to determine whether there are other factors that have influenced that treatment. And in the event of, for example, an increase in the complaints, note which symptoms are then increasing.
- Determine whether yet more activities must be added to the functional questionnaire. For example cycling and working with the hands was regularly stated in this research as often occurring functional problems.

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