ITALIAN JOURNAL OF PHYSIOTHERAPY

OFFICIAL JOURNAL OF THE ITALIAN SOCIETY OF PHYSIOTHERAPHY

VOLUME 2
NUMBER 2
JUNE 2012

EDITORIAL

About the physiotherapists education.
Gatti R.

ORIGINAL ARTICLES

A game-console to improve balance in Parkinson Disease: preliminary results using the Nintendo Wii.
Pelosin E., Avanzino L., Trompetto C., Marinelli L., Marchese R., Abbruzzese G.

Effects of continuous training programme on psychosocial status and C- reactive protein in men with essential hypertension: a randomized controlled trial.
Lamina S., Okoye G. C.

Are there differences in motor recovery between upper and lower limbs in hemiplegic patients with hemorrhagic stroke?
Paci M., Nannetti L., Moretti S., Boccaletti E., Lombardi B.

Surface electromyography pattern of masseter, orbicularis oris and submental muscles during swallowing of different consistencies in healthy subjects.
Corti G., Ghiggi A., Murelli M., Tettamanti A.

SIF
Società Italiana
di Fisioterapia

PUBLISHED BY MINERVA MEDICA

ITALIAN JOURNAL OF PHYSIOTHERAPY

OFFICIAL JOURNAL OF THE ITALIAN SOCIETY OF PHYSIOTHERAPY

ITALIAN JOURNAL OF PHYSIOTHERAPY
Official Journal of the Italian Society of Physiotherapy

Editorial address: Edizioni Minerva Medica - Corso Bramante 83-85 - 10126 Torino (Italy) - Tel. +39 011 67.82.82 Fax +39 011 67.45.02

Business, graphic, typesetting and advertising address: Edizioni Minerva Medica - Corso Bramante 83-85 - 10126 Torino (Italy) - Tel. +39 011 67.82.82 - Fax +39 011 67.45.02 - E-mail: minervamedica@minervamedica.it - Web Site: www.minervamedica.it

Printing: Edizioni Minerva Medica - Tipografia di Saluzzo - Corso IV Novembre 29-31 - 12037 Saluzzo (CN) (Italy) - Tel. +39 0175 24.94.05 - Fax +39 0175 24.94.07

Online annual subscription:
Italy – *Individual:* Online € 85; *Institutional:* Online: Small € 242, Medium € 272, Large € 314, Extra Large € 330.
European Union - *Individual:* Online € 145.00; *Institutional:* Online: Small € 242, Medium € 272, Large € 314, Extra Large € 330.
Outside European Union - *Individual:* Online € 160.00; *Institutional:* Online: Small € 265, Medium € 295, Large € 340, Extra Large € 355.

Subscribers: Payment to be made in Italy: a) by check; b) by bank transfer to: Edizioni Minerva Medica, INTESA SANPAOLO Branch no. 18 Torino. IBAN: IT45 K030 6909 2191 0000 0002 917 c) through postal account no. 00279109 in the name of Edizioni Minerva Medica, Corso Bramante 83-85, 10126 Torino; d) by credit card Diners Club International, Master Card, VISA, American Express. Foreign countries: a) by check; b) by bank transfer to: Edizioni Minerva Medica, INTESA SANPAOLO Branch no. 18 Torino. IBAN: IT45 K030 6909 2191 0000 0002 917; BIC: BCITITMM c) by credit card Diners Club International, Master Card, VISA, American Express.
Notification of changes to mailing addresses, e-mail addresses or any other subscription information must be received in good time. Notification can be made by sending the new and old information by mail, fax or e-mail or directly through the website www.minervamedica.it at the section "Your subscriptions - Contact subscriptions department".

Quarterly publication. Authorisation of the Milan Court no. 140 of March 8, 2011. Entered in the national press register in accordance with art 11 of law 416 dated 5-8-1981 at number 00 148 vol. 2 sheet 377 on 18-08-1982

ITALIAN JOURNAL OF PHYSIOTHERAPY

Vol. 2 June 2012 No. 2

Società Italiana di Fisioterapia

CONTENTS

43
EDITORIAL
About the physiotherapists education
Gatti R.

45
ORIGINAL ARTICLES
A game-console to improve balance in Parkinson Disease: preliminary results using the Nintendo Wii
Pelosin E., Avanzino L., Trompetto C., Marinelli L., Marchese R., Abbruzzese G.

50
Effects of continuous training programme on psychosocial status and C- reactive protein in men with essential hypertension: a randomized controlled trial
Lamina S., Okoye G. C.

59
Are there differences in motor recovery between upper and lower limbs in hemiplegic patients with hemorrhagic stroke?
Paci M., Nannetti L., Moretti S., Boccaletti E., Lombardi B.

65
Surface electromyography pattern of masseter, orbicularis oris and submental muscles during swallowing of different consistencies in healthy subjects
Corti G., Ghiggi A., Murelli M., Tettamanti A.

About the physiotherapists education

R. GATTI

San Raffaele Scientific Institute, Milan, Italy

The education of physiotherapists is even more intriguing than the discipline they study: physiotherapy.

Over the years some articles have been published about the best education to give to physiotherapy students. The “traditional learning” has been integrated with other educational approaches such as the “case based learning” and the “problem based learning”.[1-3] In the “traditional learning” the role of the teacher is the foundation for the students’ learning and the connection between theory and practice is not facilitated. In the other two approaches the students themselves are protagonists of their learning and the link between theory and practice is facilitated with activities as, for example, problem solving. The “traditional learning” would seem the most effective approach in the basic sciences learning. The “case based” and the “problem based” approaches would seem more adequate for the clinical practice learning, lifelong learning and for facilitating the habit of asking clinical questions. However, these two approaches would increase the students’ risk of dispersion, considering the amount of didactic activities they are involved. There is not an agreement about the approaches adopted by the Universities and some Physiotherapy Degree Courses change the approach basing on the year of Course attended by the student. The “traditional approach” is preferred during the first year, whereas the other approaches are more used during the last years.

Clinical activity can also be proposed to the students in different ways. For example an aspect that has been largely considered by the literature is the best tutor/students ratio.[4] There are many possibilities: 1 tutor and 1 student, one tutor and more students, more tutors and more students without a specific reference tutor. The classic relationship 1 tutor and 1 student gives the tutor the possibility to give the student a great attention but decreases the development of the students’ professional autonomy. The situation of one tutor and more students on one hand does not facilitate the tutors attention towards the students and the students’ attention to the patients but, on the other hand, it encourages the collaboration among the students and the transfer of competences among them. Once again, there is not a supremacy of a model on the others. The characteristics of the clinical environment and especially the characteristics of the single student must guide to the best choice.

Also the best teaching model does not meet the complexity of the physiotherapists education.

In fact it is impossible to learn many contents of the physiotherapy discipline without a direct contact with expert colleagues who transfer their professional abilities to the students. Moreover, the contents of physiotherapist education must also consider all the aspects regarding each scientific discipline connected with the health care field, such as anatomy, physiology etc, the scientific update by international literature and the ability of planning a scientific research. Finally, the management of the relationship between the physiotherapist and the patient requires the physiotherapist to be aware of the difficulty that the patients are living. The development of this awareness is a personal and intimate journey, facilitated by the questions arising from the relationship with suffering people.

The education of the physiotherapists must integrate these three different components: transfer of the skills, contents and methodology of a scientific discipline and attitude to the relationship with suffering people. Few other professions require an education that has to integrate aspects such different. Just look at the increasing number of professions that can be exerted getting a degree on-line. An education similar to the physiotherapists are some other health care professions. For example, the methodology contents and the attitude towards the patients are important for the nurses and the manual skills and the scientific education are important for a surgeon.

Is there a teaching model that considers all the components of the physiotherapist education? Since the competences (professional, scientific and relational) are different the teaching models need to be composed by different components. What is the point of synthesis among these different components that physiotherapy students have to develop?

Over the years my didactic experience suggested me that the connection among the components of the physiotherapy education is given by the students ability to make links. Moreover, it is possible to develop this ability only when the meaning of the profession is clear. To make this possible the student has to be astonished looking at the work of a more expert colleague.

What huge responsibility for the colleagues involved in the physiotherapists education. For them the education of physiotherapy students is very intriguing.

References

1. Rowe M, Frantz J, Bozalek V. The role of blended learning in the clinical education of healthcare students: a systematic review. Med Teach 2012;34:216-21.
2. Saarinen-Rahiika H, Binkley JM. Problem-based learning in physical therapy: a review of the literature and overview of the McMaster University experience. Phys Ther 1998;78:195-207.
3. Thistlethwaite JE, Davies D, Ekeocha S, Kidd JM, MacDougall C, Matthews P *et al.* The effectiveness of case-based learning in health professional education. A BEME systematic review: BEME Guide No. 23. Med Teach 2012;34:421-44.
4. Lekkas P, Larsen T, Kumar S, Grimmer K, Nyland L, Chipchase L *et al.* No model of clinical education for physiotherapy students is superior to another: a systematic review. Aust J Physiother 2007;53:19-28.

Received on June 29, 2012 - Accepted for publication on July 3, 2012.

Corresponding author: R. Gatti, San Raffaele Scientific Institute, Milan, Italy.
E-mail: roberto.gatti@sif-fisioterapia.it

A game-console to improve balance in Parkinson Disease: preliminary results using the Nintendo Wii

E. PELOSIN [1], L. AVANZINO [2], C. TROMPETTO [1], L. MARINELLI [1], R. MARCHESE [1], G. ABBRUZZESE [1]

[1]Department of Neuroscience, Ophthalmology, and Genetics, University of Genoa, Genoa, Italy
[2]Department of Experimental Medicine, Section of Human Physiology, University of Genoa, Genoa, Italy

ABSTRACT

Aim. Balance impairment is a common problem in idiopathic Parkinson's disease (PD) often responsible for increased risk of falls, mobility restriction and loss of independence. Conventional exercises are often repetitive and may induce patients to lose their interest and to interrupt physical therapy at home. This study was aimed at evaluating theeffect of 5 days training with a low-cost, commercially available playing system, the Nintendo Wii® (NW), in improving balance in PD.
Methods. Ten patients with PD and ten aged-match normal subjects (NS) were recruited and performed 30 minutes exercises playing with NW every day for one week. Subjects were evaluated by means of static posturography and Berg Balance Scale (BBS) before and after training.
Results. The 5-day training, based on video-game system, induced a significant decrease in all the posturographic parameters in both groups improving postural stability of PD to a level comparable to baseline condition in NS. BBS score improved after training in PD patients.
Conclusion. These preliminary results suggest that a video game-based approach can exert a positive effect improving postural stability in PD patients. Because the NW device promotes better compliance, has wide applicability and is enjoyable to use, this treatment concept holds promise for PD rehabilitation. *(It J Physiotherapy 2012;2:45-9)*

Key words: Parkinson disease - Physical therapy modalities - Rehabilitation.

Postural instability is a common feature of Parkinson's disease (PD) and it represents a highly disabling and poorly treatable symptom that predisposes patients to falls.A large number of studies in PD confirmed that a constant regimen of dynamic exercise combined with physical therapy is successful in improving motor control, balance and physical function.[1] However, most programs are based on health facilities or physical therapy settings involving travel and costs for the patients and such limitations make the therapeutic intervention often inaccessiblefor people with PD. In the last years, several strategies have been developed to overcome these limitations, such as biofeedback computer interface [2] and virtual reality,[3-7] demonstrating that the use of rewarding activities improves not only motor performance but also the patients' motivation to practice. Indeed it has been demonstrated that new rehabilitation technologies such as Virtual Reality have positive effect in balance and walking performance in patients withPD.[8, 9]

Recently, Nintendo Wii™ (NW), a home video game console (©Nintendo Inc.), was released. NW is equipped with a Balance Board (BB), a bluetooth device containing multiple pressure sensors that are used to measure the user's shifts in weightbalance. Through this system each user

Table I.—*Subjects' characteristics at baseline.*

Normal Subjects	Age (ys)	Gender	Pd patients	Age (ys)	Gender	Disease Duration (YS)	UPDRS III	H&Y Stage	Drugs
NS01	71	M	PD01	66	M	8	15	1.5	DA
NS02	69	F	PD02	61	M	5	10	1.5	DA
NS03	49	F	PD03	52	F	5	14	1.5	LD + DA
NS04	50	M	PD04	54	M	7	21	2	DA
NS05	72	M	PD05	68	F	14	22	2.5	LD + DA
NS06	57	F	PD06	72	F	12	27	2	LD + DA
NS07	55	F	PD07	76	M	10	23	2	LD + DA
NS08	73	M	PD08	67	M	6	20	2	LD + DA
NS09	74	M	PD09	74	M	12	22	2.5	LD + DA
NS10	62	F	PD10	58	F	7	13	1.5	LD + DA

NS: normal subject; PD: Parkinson's disease; M: male; F: female, LD: levodopa, DA: dopamine agonist

can control on-screen gaming action with movements in real time.

On the basis of all these findings, we investigated if using a NW we can improve balance in patients with PD by using exercises selected to improve postural stability.

Materials and methods

Ten patients with idiopathic PDand ten normal subjects (NS) entered in this pilot study (Table I). All patients were on a stable medication regimen. They were specifically selected because they presented with postural instability. Diseases severity was determined by means of the Unified Parkinson's Disease Rating Scale (UPDRS - Part III Motor) and all patients were in Hoehn&Yahr stages 1 to 2.5.None of the patients had a significant cognitive impairment (Mini-Mental State Examination: >24), a past history of orthopedic or other gait-influencing diseases, or neurosurgical procedures.

Postural parameters such as Sway Area (SA),Sway Path (SP), X-axis maximal oscillation (MO*x*) and Y-axis maximal oscillation (MO*y*) were measured using a stabilometric platform (ARGO™), while the Berg Balance Scale (BBS) was used to evaluate balance performance and abilities.During the stabilometric measurements all participants were asked to stand still with eyes closed (EC), with their feet together (FT) and the arms kept by the subjects' sides; each stabilometric trial lasted 60 s. Subjects were tested before the physical therapy program (PRE) and one day after the end of the entire cycle of 5 training sessions (POST5).

All participants underwent a 30 minute period of exercises playing with NW and itscustomized software Wii-fit™,every day for one week. To prevent the potential fall associated with the use of gaming consoles, subject's were instructed how to play so as to ensure participants' safety. Training was performed monitored by a physical therapist in the out-patient Movement Disorders Clinic of the University of Genoa. The complexity of the exercises was progressively increased and the maximum game-level reached depended on the subjects' ability. All patients gave their written informed consent and the study was conducted in accordance with the Declaration of Helsinki.

Statistical analysis

Data at baseline were analyzed for normality according to the Shapiro-Wilk test. An unpaired t-test was used to analyze possible differences in posturographic parameters between PD patients and NS at the baseline. Then, to evaluate the effect of NW training we performed, separately for each posturographic parameter, a Repeated Measure Analysis of Variance(RM-ANOVA) with TIME (PRE, and POST) as within subjects factor and GROUP (PD and NS) as between subjects factor. When the RM-ANOVA gave a significant result ($P<0.05$), the post-hoc Bonferroni test was

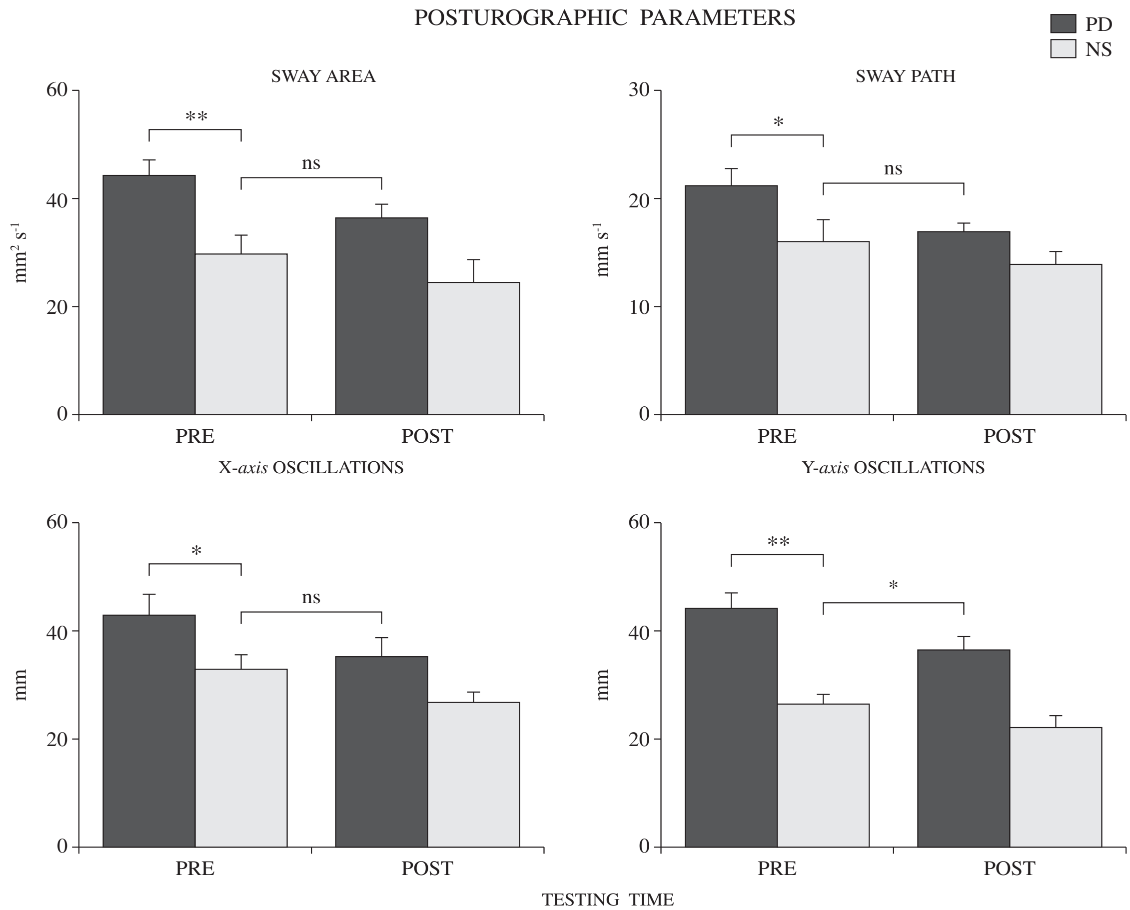

Figure 1.—Posturographic Parameters. Comparison of all posturographic parameters for each group (PD, NS) across time (PRE-POST). Columns represent the mean value (+/-SE) during 60s recording of feet-together condition. Results obtained at baseline evaluation (PRE) showed significant differences between PD and NS for all parameters. However, after training, only oscillations in the sagittal plane (Y-*axis* OSCILLATIONS) remained significantly larger in patients with PD, with respect to the baseline values of NS. Asterisks (*,**) indicate respectively P<0.05, P<0.001; the acronym “ns” indicate that statistic analysis was “not significant”.

employed to assess significant differences among groups and testing times. To directly analyze if WII training was able to improve postural stability of patients to a level comparable to baseline condition in NS we performed an unpaired t-test between PRE condition of NS and POST5 condition of PD. Berg Balance score before and after the 5 sessions of exercise was compared with the paired t-test in patients with PD.

Results

At baseline evaluation all the posturographic parameters were significantly different between patients with PD and NS (unpaired t test: SA area P=0.002; SP P=0.032, MOx P=0.034; MOy P=0.0001), suggesting increased body oscillations and postural instability in PD.

The 5-day training with Wii-Fit™induced a significant decrease in all the posturographicparameters in PD (values reported as Mean±SE; SA: PRE (47.6±4.3 mm^2*s^{-1}); POST (35.7±3.2 mm^2*s^{-1}); SP: PRE (21.3±1.5 $mm*s^{-1}$); POST (16.9±0.9 $mm*s^{-1}$); MOx: PRE (42.7±3.8 mm); POST (35.1±3.6 mm)PRE ; MOy: PRE (44.2±2.9 mm); POST (36.4±2.5 mm)) and NS(values reported as Mean±SE; SA: PRE (29.9±2.6 mm^2*s^{-1}); POST (24.6±3.4 mm^2*s^{-1}); SP: PRE (16.1±1.6 $mm*s^{-1}$); POST (13.9±0.9 $mm*s^{-1}$); MOx: PRE (32.8±2.2 mm); POST

(26.7±1.6 mm)PRE ; MOy: PRE (26.5±1.4 mm); POST (22.2±1.7 mm)). Accordingly, for all the parameters, RM-ANOVA showed a significant effect of TIME (P always <0.01).Further, the SAwas reduced more in PD patients than in NS: RM-ANOVA showed a significant interaction TIME*GROUP (P=0.005) and post hoc analysis revealed that while in PRE condition the SA was larger in patients with PD than in NS (P=0.002), after training no significant difference was found between PD and NS (P=0.67). No significant interaction TIME*GROUP was found for the other postural parameters.

The 5-day training with NWwas able to improve most posturographic parameters of patients with to a level comparable to the baseline values observedin NS (P always >0.05). After training, only oscillations in the sagittal plane (MOy) remained significantly larger in patients with PD, with respect to the baseline values of NS (P=0.002).

The BBS score was significantly improved at the end of the physical therapy training (PRE: mean 39.1±2.89 SD; POST:mean 44.9±2.81 SD; paired t test, PRE and POST: P<0.001).

Discussion

This pilotstudy was aimed at investigating if the use of a video-game system is feasible and helpful in therehabilitation of patients with PD.

A 5-day training program with NW was sufficient to improve postural stability in PD on the basis of both clinical and posturographic evaluation. Thus far, data available in the literature regarding static posturography in PD has shown contradictory results. Indeed, several studies showed that the body sway of patients with PD is similar to that of age-matched normal subjects,[10] while others reported either a decrease in postural sway [11] or an increase of spontaneous sway indices.[12] In the present study, at basal evaluation, we found significantly larger values of all the posturographic parameters in patients with PD than in controls. Our results are likely to be the consequence of the experimental protocol chosen in the present study: we selected a position of the feet (feet together) and the eyes closed condition that have been reported by other studies to be the most unstable not only in healthy volunteers[13] but above all in patients with PD. Further it has been demonstrated that increase in postural parameters are dependent not only on visual conditions but also on specific postural dysfunctionscharacteristic for the PD.[14]

At the end of the training period, we observed a reduction of all the posturographicparameters in both groups (NS and PD). However, a larger reduction of SA was present in patients with PD. Further, we found that the 5-day training with NW was able to improve SA, SP and Moy of patients with PD to a level comparable to baseline values of NS. The value of MOx did not improve to the same extent in our patients and we believe that this finding might be attributed to the typical flexed posture of subjects with PD that is likely to be less sensitive to this type of rehabilitative approach.[12]

The most striking result of this study is that a significant improvement on postural stability could be observed after a short and intensive training. This effect can be related to the fact that the exercises selected in this training protocol, thanks to visual and auditory augmentedfeedbacks (*i.e.*,intensity of repetitions, rewarding, emulation of a teacher)and to mirroring, based on imitation of movements, should contribute to enhance positive results in motor performance.

To date, conventional exercises for balance training have been demonstrated to be often repetitive, scarcely engaging, and rarely related to activities of daily living. To promote patients' involvement and to improve the training efficacy, new devices have been recently introduced in the clinical practice, but data present in the literature are conflicting. According to a meta-analysis,[15] the Center of Pressure (COP) biofeedback training was able to improve most of the posturography parameters, but not balance performance during daily functional activities. On the other hand, studies employing virtual reality showed a positive effect in improving motor performance and daily livingactivities, but presented some restrictions such as the constraint of having a physical therapist present, the limited period of treatment and the equipment costs. The NW is inexpensive and capable of providing repeated sessions of treatment for an indefinite period of time inanecological situationathome. Indeed, this systempresents several features suitable for balance training: 1) it provides continuous visual feedback regarding COP position in space; 2) it is equipped with various auditory feedbackthat helps the subjects in improving their performance; and 3) it stimulates mirroring mechanisms that produce an ongoing feedback about actual *vs.* intended movement.

The positive results on postural stability observed in this pilot study suggest that the use of a commercial video-game might be helpful in motivating people with PD to perform exercises on their own while also "having fun." Further studies should be done exploring the possibility of using the NW games as a effective tools for home-training in addition to a rehabilitation programs.

The full potential of video-game systems as a component of home tele-rehabilitation of patients with PD should be as previously suggested[16].

References

1. Dibble LE, Addison O, Papa E. The effects of exercise on balance in persons with Parkinson's disease: a systematic review across the disability spectrum. J NeurolPhysTher 2009;33:14-26.
2. Gourlay D, Lun KC, Lee YN, Tay J. Virtual reality for relearning daily living skills. Int J Med Info 2000;60:255-61.
3. Lange B, Flynn S, Proffitt R, Chang CY, Rizzo AS. Development of an interactive game-based rehabilitation tool for dynamic balance training. TopStroke Rehabil 2010;17:345-52.
4. Koritnik T, Koenig A, Bajd T, Riener R, Munih M. Comparison of visual andhaptic feedback during training of lower extremities. Gait Posture 2010;32:540-46.
5. Kohler F, Schmitz-Rode T, Disselhorst-Klug C. Introducing a feedback training system for guided home rehabilitation. J NeuroengRehabil 2010;15:7-12.
6. Morelli S, Maccioni G, Lanzetta M, Macellari V, Giansanti D. A home-care system for the telemonitoring and telerehabilitation of the hand incorporating interactive biofeedback. J TelemedTelecare 2008;14:372-76.
7. Laver KE, George S, Thomas S, Deutsch JE, Crotty M. Virtual reality for stroke rehabilitation. Cochrane Database Syst Rev 2011:7;9.
8. Mirelman A, Maidan I, Herman T, Deutsch JE, Giladi N, Hausdorff JM. Virtual reality for gait training: can it induce motor learning to enhance complex walking and reduce fall risk in patients with Parkinson's disease? J Gerontol ABiolSci Med Sci 2011;66:234-40.
9. Yen CY, Lin KH, Hu MH, Wu RM, Lu TW, Lin CH. Effects of virtual reality-augmented balance training on sensory organization and attentional demand for postural control in people with Parkinson disease: a randomized controlled trial. PhysTher 2011;91:862-74.
10. Schieppati M, Nardone A. Free and supported stance in Parkinson's disease. The effect of posture and "postural set" on leg muscle responses to perturbation, and its relation to the severity of the disease. Brain 1991;114:1227-44.
11. Horak FB, Nutt JG, Nashner LM. Postural inflexibility in parkinsonian subjects. J NeurolSci 1992;111:46-58.
12. Błaszczyk JW, Orawiec R, Duda-Kłodowska D, Opala G. Assessment of postural instability in patients with Parkinson's disease. Exp Brain Res 2007;183:107-14.
13. Letz R, Gerr F. Standing steadiness measurements: empirical selection of testing protocol and outcome measures. NeurotoxicolTeratol 1995;17:611-6.
14. Marchese R, Bove M, Abbruzzese G. Effect of cognitive and motor tasks on postural stability in Parkinson's disease: a posturographic study.MovDisord 2003;18:652-8.
15. Barclay-Goddard R, Stevenson T, Poluha W, et al. Force platform feedback for standing balance training after stroke. Cochrane Database Syst Rev 2004;18:CD004129.
16. Yavuzer G, Senel A, Atay MB, Stam HJ. ''Playstationeyetoy games" improve upper extremity-related motor functioning in subacute stroke: a randomized controlled clinical trial. Eur J PhysRehabil Med 2008;44:237-44.

Received on December 16, 2011 - Accepted for publication on June 28, 2012.

Corresponding author: E. Pelosin, Department of Neuroscience, Ophthalmology, and Genetics, University of Genoa, Largo Daneo 3 (ex via de Toni 5), 16132 Genoa, Italy. E-mail: elisapelosin@yahoo.it

Effects of continuous training programme on psychosocial status and C- reactive protein in men with essential hypertension: a randomized controlled trial

S. LAMINA [1], G. C. OKOYE [2]

[1]Biomedical Technology Department, School of Health Technology, Federal University of Technology, Owerri, Nigeria; [2]Medical Rehabilitation Department, Faculty of Health Science and Technology, University of Nigeria, Enugu Campus, Enugu, Nigeria

ABSTRACT

Aim. Both chronic psychosocial stress and C-reactive protein (CRP) has been implicated in the aetiology of cardiovascular disease. However, the effect of aerobic training on psychosocial stress and CRP in hypertensive management in black African population is scanty and unclear. The purpose of the present study was to determine the effect of continuous training on psychosocial status and CRP in black African subjects with hypertension.
Methdos. The study design was a randomized controlled trial. Three hundred and fifty seven male patients with mild to moderate (systolic blood pressure [SBP] between 140-180 and diastolic blood pressure [DBP] between 90-109 mmHg) essential hypertension were age matched and randomly grouped into continuous and control groups. The continuous group involved in an 8 weeks continuous training (60-79% HR max) of between 45minutes to 60 minutes, 3 times per week, while the control group remain sedentary. SBP, DBP, VO2max, CRP and psychosocial status were assessed. Analysis of covariance (ANCOVA) and Pearson correlation test were used in data analysis.
Results. Findings of the study revealed significant effect of continuous training programme on VO2max, SBP, DBP, CRP and psychosocial status at $P<0.05$. Psychosocial status is significantly and negatively correlated with CRP (-0.560). Also, Psychosocial status is significantly and positively correlated with VO2 max ($r=0.399$) at $P<0.01$.
Conclusion. The present study demonstrated a rationale bases for the adjunct therapeutic role of moderate intensity continuous exercise training in the down regulation of blood pressure, CRP and psychosocial stress in the management of hypertension. *(It J Physiotherapy 2012;2:50-8)*

Key words: Hypertension - Blood pressure - C- reactive protein - Africa.

Hypertension is particularly prevalent among African subjects, with 59% being affected.[1, 2] Because of the high and increasing prevalence of hypertension and its concomitant risks of cardiovascular events (such as stroke, kidney disease, decreased disability adjusted and mortality), hypertension has been claimed to be a major global health problem and public-health challenge; demanding a vast proportion of health care resources directly and indirectly.[3, 4] Chronic psychosocial stress has been implicated in the aetiology of hypertension.[5, 6] In African American population, factors such as socioenvironmental and psychosocial stress have been associated with higher blood pressure.[7] Stress reduction may be useful for treating hypertension, yet there has been lack of controlled clinical trials of stress reduction in the management of hypertension.[8]

Epidemiological studies have shown that increased levels of physical activity reduce the incidence of all-cause mortality and cardiovascular-related deaths.[9] Although the mechanisms responsible for this benefit are not fully understood, exercise is known to have favorable effects on such traditional risk factors as elevated blood pressure (BP), hyperinsulinemia, and hyperlipidemia. Studies have also shown that exercise cannot only induce beneficial physiological adaptations, but can also improve psychological functioning.[10-13]

McDade *et al.*[14] hypothesized that inflammation may be a mechanism through which stress facilitates progression of cardiovascular (CV) disease, and therefore sought to determine the contribution of psychosocial stress to C-reactive protein (CRP) levels. Subjects were a representative sample of middle-aged and older adults. They report significant relationship between the levels of CRP and perceived stress. Ranjit *et al.*[15] looked at the association between psychosocial factors and the inflammatory indicators IL-6, CRP, and fibrinogen. They reported a positive correlation between chronic stress and higher levels of IL-6 and CRP. These studies demonstrate the impact of psychosocial stress on the inflammatory process in general and more specifically on CRP. Psychosocial stress is seen to positively correlate with the inflammatory markers IL-6 and CRP, and CRP in turn positively correlates with incidents of ischemia triggered by mental stress.

One mechanism of action that has been proposed to explain the psychosocial stress and CRP connection incorporates the autonomic nervous system. An increased psychosocial stress could increase the sympathetic activity, promoting the release of proinflammatory cytokines,[16] and finally resulting in an increase of CRP. Likewise, psychosocial stress could decrease parasympathetic activity, thus further promoting the release of proinflammatory cytokines.[17] A cross-sectional study has shown that individuals who are more active or physically fit have lower cardiovascular responses to stress.[18] However, longitudinal studies generally demonstrated that heart rate (HR) and BP levels are attenuated after exercise training in healthy and hypertensive subjects.[19,20] To best of our knowledge, there are few large randomized controlled trials investigating the association between exercise training and psychosocial status in hypertension, and of those few studies, none has investigated these effects on pure black African population. However, heredity [21] and genetical [22] factors have been implicated in the causative of hypertension. There is also the possibility of the effects of apolipoprotein (apo) E, angiotensin-converting enzyme (ACE), interleukin-6(IL-6) [23] and lipoprotein lipase (LPL) genotypes in responses to exercise and physical activity in hypertension.[24] These interpersonal and interracial differences clearly indicate the needs for study on pure older black African population. Therefore, the purpose of the present study was to investigate the effect of continuous training programme on blood pressure, CRP and psychosocial stress of pure black African subjects with hypertension.

Materials and methods

Study design

In the present study, age-matched randomized independent pretest-posttest-control group design was used to determine the influence of the continuous training programme psychosocial status and CRP.

Subjects

The population for the study was male essential hypertensive subjects attending the hypertensive clinic of Murtala Muhammed Specialist Hospital Kano Nigeria. Subjects were fully informed about the experimental procedures, risk, and protocol, after which they gave their informed consent.

Inclusion criteria

Only those who volunteered to participate in the study were recruited. Subjects between the age range of 50 and 70 years with chronic mild to moderate and stable (>1 year duration) hypertension (systolic blood pressure [SBP] between 140-179 and diastolic blood pressure [DBP] between 90-109 mmHg) were selected. Only those who had stopped taking antihypertensive drugs or on a single antihypertensive medication were recruited.[25] They were sedentary and have no history of psychiatry or psychological disorders or abnormalities.

Exclusion criteria

Obese or underweight (BMI between 20 and 30 kg/m^2), smokers, alcoholic, diabetic, other cardiac, renal, respiratory disease patients were excluded. Those involved in vigorous physical activities and above averagely physically fit (VO_2max >27 and >33 mL/kg.min for over 60 and 50 year old, respectively) were also excluded.

Intervention

Outcome measures

The study outcome measures included the SBP, DBP, VO_2max, CRP and psychosocial status

Procedures

Pretest procedure

Pretest Wash out Period: All subjects on antihypertensive drugs were asked to stop all forms of medication and in replaced, were given placebo tablets (consisted of mainly lactose and inert substance) in a double blind method.[26] Also subjects including those not on any antihypertensive medications were placed on placebo tablets for one week (7 days); this is known as "Wash out period". The purpose of the wash out period was to get rid of the effects of previously taken antihypertensive drugs/medications. During the wash out period all subjects were instructed to report to the hypertensive clinic for daily blood pressure monitoring and general observation. All pretest procedures were conducted at the last day of the wash out period.

Subjects resting (pre training) heart rate (HR), SBP, and DBP were monitored from the right arm as described by Musa *et al.*[27] using an automated digital electronic BP monitor (Omron digital BP monitor, Medel 11 EM 403c; Tokyo Japan).

Anthropometric measurement: Subjects' physical characteristics (weight [kg] & height [m]) and body composition (Body Mass Index [BMI] (kg/m^2)) assessment was done in accordance with standardized anthropometric protocol.[28, 29]

Blood Sample Collection (Venipuncture Method): Pre-treatment venous blood samples were obtained after about 12 hour overnight fast (fasting blood sample). Five ml syringe was used for blood sample collection, using the procedure described by Bachorik.[30]

C-reactive protein: The high-sensitivity CRP was determined qualitatively and semiquantitatively using a commercial latex agglutination method.[31]

Psychosocial assessment.—Subjects were in a comfortable sitting position and were given the General Well Being (GWB) Schedule questionnaires. Subjects were instructed to respond to the subscales of the 18 items questions for a maximum of 20 minutes and the questionnaires were collected immediately. High values indicate high psychosocial wellbeing or decrease psychosocial stress. The questionnaire was developed and validated by the National Centre for Health Statistics.[32]

Pretest stress test.—The Young Men Christian Association (YMCA) submaximal cycle ergometry test protocol was used to assess subject's aerobic power (VO_2max) as described by ACSM.[33] The stress test (pre & post training) was conducted under the supervision of experts in basic life support care and the emergency unit of the hospital was made ready to accommodate any incident that might occur during the stress test.

Test (training) procedure

Training programme: Following stress test and prior to the exercise training, all subjects in both control and continuous groups were re-assessed by the physician and were prescribed with antihypertensive drug; methyldopa as necessary. Methyldopa was preferred because it does not alter normal hemodynamic responses to exercise [34] and it is a well-tolerated antihypertensive drug in the Africa [35] and mostly prescribed in the northern part (Kano) of Nigeria where the study was conducted and useful in the treatment of mild to moderately severe hypertension.[36] Subjects maintain these prescriptions with regular medical consultation and observation through-out the period of exercise training.

Intervention

The continuous group (group 1): Subjects in the continuous group exercised on a bicycle ergometer at a low intensity of between 60-79% of their HR max as recommended by ACSM [37]. The starting workload was 100 kgm (17 watts) at a pedal speed of 50rpm; the workload was later increased to obtain a HR max reserve of 60%. This was increased in the first two weeks to and levelled up at 79% HR max reserve throughout the remaining part of the training period. The initial of exercise session was increased from 45 minutes in the first two weeks of training to and leveled up at 60 minutes throughout the remaining part of the training. Exercise session of three times per week was maintained throughout the 8 weeks training period for continuous group.

The control group (group 2): Subjects in the control group were instructed not to undertake any vigorous physical activity during the 8weeks period of study.

Post-test procedure

Posttest wash out Period**:** At the end of the 8 weeks training period, all subjects were asked to stop methyldopa and subjects were prescribed with placebo tablets for one week as in pretest procedure.

Posttest SBP, DBP, CRP, psychosocial status assessment and posttest stress test were conducted as earlier described in the pretest procedures using standardized protocols, techniques and methods. All posttest procedures were conducted at the last day of the posttest wash out period.

Statistical analysis

Following data collection, the measured and derived variables were statistically analized. The descriptive statistics (Means and standard deviations) of the subjects' physical characteristics, estimated VO_2 max, CRP, psychosocial status, and cardiovascular parameters were determined. Student's t-test was used to compare groups' physical and baseline characteristics. Analysis of covariance (ANCOVA) was used to assess treatment outcomes; in the ANCOVA, the post-test values were the outcome variables and pretest values as covariates. Pearson product moment correlation test were computed for the variables of interest. In the correlation test, changed score (the difference between subjects post-training and pre-training measurements) were used as dependent measures. All statistical analysis was performed on a Toshiba compatible microcomputer using the statistical package for the social science (SPSS), (Version 16.0 Chicago IL, USA). The probability level for all the above tests was set at 0.05 to indicate significance.

Results

A total of 323 chronic and stable, essential mild to moderate male hypertensive patients satisfied the necessary study criteria. Subjects were aged matched and randomly grouped into experimental (162) and control (161) groups. Two hundred and seventeen subjects (112 from continuous, and 105 from control group) completed the eight weeks training program. One hundred and six subjects (50 from continuous, and 56 from control group) had dropped out because of non-compliance, unfavorable responses to methyldopa and exercise training or had incomplete data; therefore, the data of 217 subjects (continuous [112] and control [105]) were used in the statistical analysis (Figure 1).

The subjects' age ranged between 50 and 70 years. Mean age, height, weight and BMI: of subjects in continuous exercise group were (58.63±7.22 years, 1.73±6.97 m, 67.49±10.16 kg, 22.48±2.89 $kg.m^{-2}$) respectively while for the Control group Mean age, height, weight and BMI were (58.27±6.24 years, 1.68±5.31 m, 68.47±17.07 kg, 23.37±5.31 $kg.m^{-2}$ respectively). There was no significant difference in age (t=0.390, P=0.697), SBP (t=0.540, P=0.597),

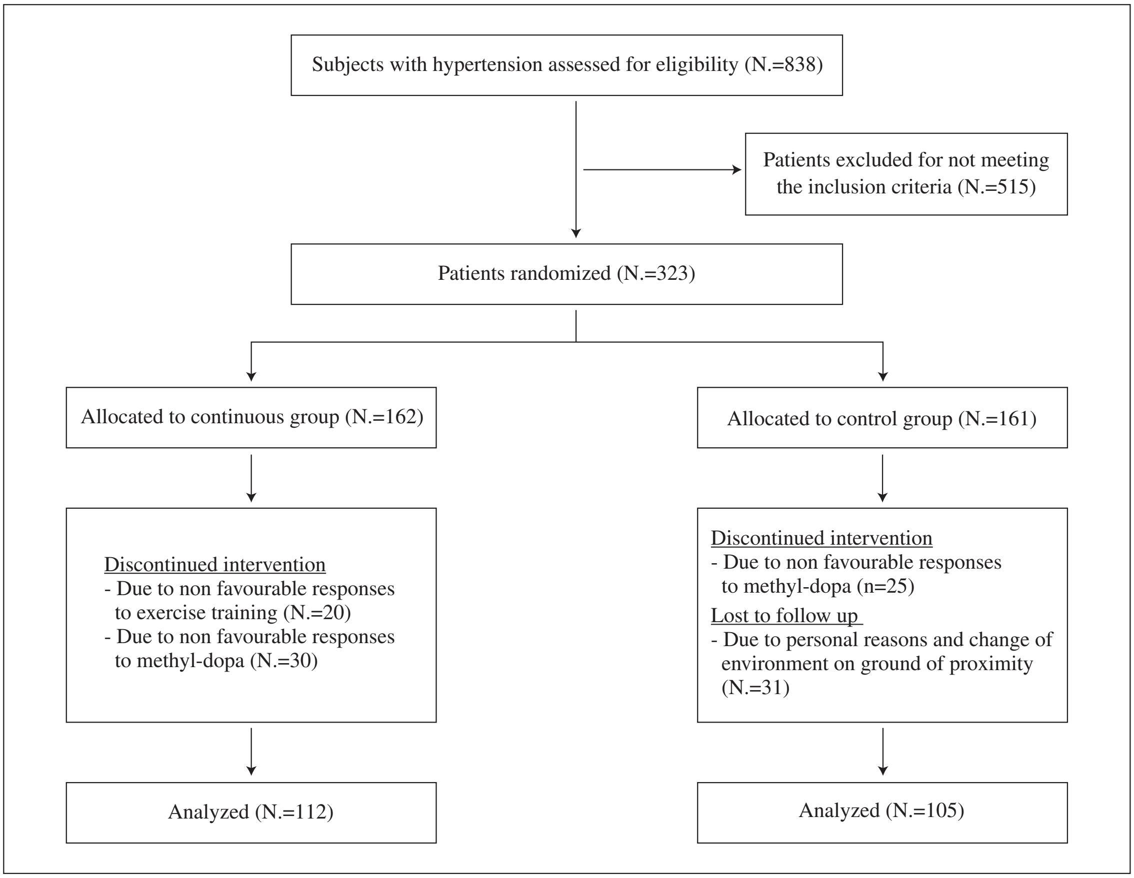

Figure 1.—Study design flow chat.

Table I.—*Groups mean± SD base line physical characteristics and Independent t-test (N.=217).*

Variables	Continuous group pretest (N.=112) X±SD	Control group pretest (N.=105) X±SD	t-values	P-values
Age (years)	58.63±7.22	58.27±6.24	0.390	0.697
SBP (mmHg)	170.45±15.57	160.87±13.23	0.540	0.597
DBP (mmHg)	97.56±7.53	97.17±1.43	0.530	0.597
VO_{2max} (ml/kg/min)	20.69±12.49	21.23±5.76	0.406	0.685
Weight (kg)	67.48±10.16	68.47±17.07	-0.514	0.608
BMI (kg/m^2)	22.92±2.20	23.37±3.87	-1.060	0.290
CRP	0.15±0.05	0.13±0.04	3.615	0.000*
GWBS	59.94±9.09	63.93±10.28	-3.38	0.03*

*Significant, P<0.05.

DBP (t=0.530, P=0.597) and VO_2max (t=-0.406, P=0.685) between groups. The physical characteristics of the subjects are comparable (Table I).

Subjects' pre- and post-treatment mean BP±SD mmHg; psychosocial status and VO_2max mL.kg^{-1}.min^{-1} for the exercise group are depicted in Table II. Groups changed score

TABLE II.—*Groups mean(X) and standard deviation (SD) pre and posttest values (N.=217).*

Variables	Continuous pretest X±SD	Continuous post-test X±SD	Control pretest X±SD	Control post-test X±SD
SBP(mmHg)	170.45±15.57	157.82±23.91	160.87±13.23	163.47±14.88
DBP(mmHg)	97.56±7.53	94.83±7.21	97.17±1.43	96.10±2.61
VO_{2max} (mL/kg/min)	20.69±12.49	28.68±13.60	21.23±5.76	22.82±7.44
GWBS	59.94±9.09	71.69±5.95	63.93±10.28	65.27±10.47
CRP (mg/L)	0.15±0.05	0.13±0.05	0.13±0.04	0.13±0.05

TABLE III.—*Groups changed scores mean(X) ± standard deviation (SD) and ANCOVA test (F) values (N.=217).*

Variables	Changed score values X±SD		F-values	P-values
	Continuous group N.=112	Control group N.=105		
SBP (mmHg)	-13.94±6.95	2.61±7.85	514.611	0.000*
DBP (mmHg)	-7.41±6.26	-1.07±1.76	488.715	0.000*
VO_2max (mL/kg/min)	7.99±6.62	1.59±3.52	698.771	0.000*
GWBS	10.44±6.23	1.33±3.15	519.972	0.000*
CRP (mg/L)	-0.02±0.04	0.01±0.03	282.104	0.000*

*Significant, P<0.05

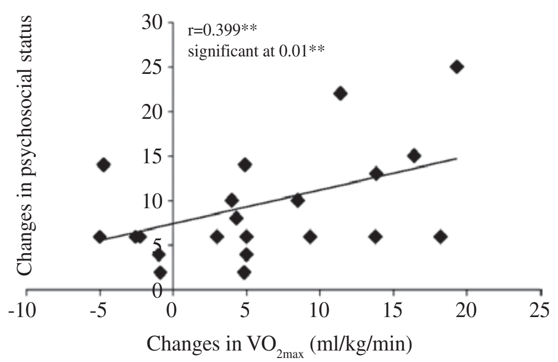

Figure 2.—Correlation between training changes in VO_2max and psychosocial status (N=112).

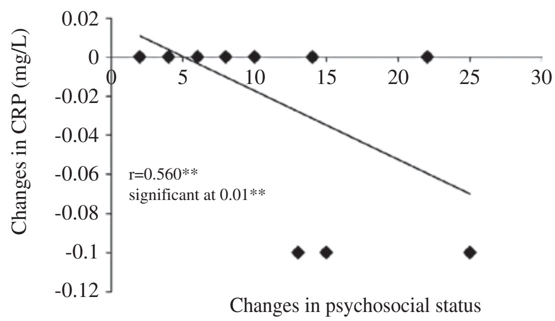

Figure 3.—Correlation between training changes in CRP and psychosocial status (N.=112).

values and ANCOVA test results (Table III) indicated a significant effect in the exercise groups over control in SBP (P=0.000), DBP (P=0.000), psychosocial status (P=0.000), CRP (P=0.000) and VO_2 max (P=0.000) at P<0.05.

There was a significant positive correlation between changes in psychosocial status and VO_2max (r=0.399) in Figure 2 and significant negative correlation between psychosocial status and CRP (r=-0.560), in Figure 3 at P<0.01.

Discussion

Findings from the present study revealed a significant decrease in SBP, DBP and increase in VO_2 max in the continuous group over control group. The favorable changes resulting from aerobic training in both SBP and DBP demonstrated in the present study is consistent with several other studies.[38, 39] Also, result of the present study indicated a significant increase in psychosocial wellbeing (reduction in psychosocial stress) and CRP in the continuous group over control group. There was a significant correlation between psychosocial stress and CRP.

The favorable changes resulting from aerobic training on psychosocial status as demonstrated in the present study is consistent with the study of Smith *et al.*,[39] they investigated the effect of aerobic exercise and weight reduction intervention on 133 sedentary hypertensive (SBP:130-180 mmHg; DBP:85-110 mmHg) males and females. Participants were grouped into aerobic group, aerobic with weight reduction group and control group, participants engaged in 6months treatment period. They reported a significant decreased in self-reported depressive syndrome in the treatment groups compare to the placebo group.

The observation in the present study is also in line with a study by Ulrik *et al.*[40] and Klocek *et al.*[41] though on heart failure and CHD patients respectively. Both studies demonstrated significant improvement in the quality of life in the interval training over continuous. The mechanism of the superior effect of intensive physical training on the quality of life is not presently known, but it is reasonable to suggest that it is due to greater physiological adaptation and thereby improved capacity for activity in interval group.

Another similar result was reported by Georgiades et al [42], in their study, they investigated the effects of exercise and weight loss on cardiovascular responses during mental stress in mildly to moderately overweight patients with elevated blood pressure. Ninety-nine men and women with high normal or un-medicated stage 1 to stage 2 hypertension; (systolic blood pressure 130 to 179 mmHg, diastolic blood pressure 85 to 109 mmHg), underwent a battery of mental stress tests, including simulated public speaking, anger recall interview, mirror trace, and cold pressor, before and after a 6-month treatment program. Subjects were randomly assigned to 1 of 3 treatments: 1) aerobic exercise; 2) weight management combining aerobic exercise with a behavioral weight loss program; or 3) waiting list control group. Their results demonstrated that exercise, particularly when combined with a weight loss program, can lower both resting and stress-induced blood pressure levels and hemodynamic pattern resembling that targeted for antihypertensive therapy.

However, a contradictory finding to the present study was reported by Pierce *et al.*[43] They investigated the effects of 16 weeks of physical exercise training on the psychological functioning of patients with mild hypertension. Ninety patients were examined at baseline and after 16 weeks of training, patients completed a psychometric test battery that included objective measures of neuropsychological performance and standardized self-report measures of psychosocial functioning. Patients were randomly assigned to 1 of 3 groups: aerobic exercise, strength training and flexibility exercise, or a waiting list control group. After training, there were no group differences on any of the psychological measures. Another contradictory finding, though, on healthy subjects was reported by Kohut *et al.*[44] In their study, they investigated the effect of aerobic exercise on psychosocial scores (depression, optimism, sense of coherence). Sixty four years healthy old adults, also sub-group of subjects treated with non selective beta (1) beta (2) adrenergic antagonist were assigned to aerobic exercise or control for 3 days/week, 45 minutes for 10 months. They reported non-significant effect of aerobic exercise compared to control on psychosocial scores.

The reasons for discrepancies in findings between the present study and others might not be unconnected to the type, mode, frequency, duration of intervention, condition of subjects that varied across studies. The mechanisms responsible for exercise-related improvements in psychosocial status are not known. However, a number of psychological factors have been proposed to explain the effect that exercise has on depressed mood including increased self-efficacy, a sense of mastery, positive thoughts, distraction from negative thoughts, and enhanced self-concept. A number of biologic pathways have also been suggested including: increased central norepinephrine neurotransmission,[45] alterations in the hypothalamo-pituitary-adrenocortical axis;[46] and increased secretion of amine metabolites as well as serotonin synthesis and metabolism.[47]Physical activity and fitness appear to have general anti-inflammatory effects, that is, an inverse relationship with several inflammatory markers including CRP. Moreover, it has been reported that increasing physical activity/fitness leads to lower CRP levels.[48] CRP has been shown to correlate with activation of the sympathetic nervous system stress response.[49] A CRP elevation in humans has also been shown to correlate with psychosocial stress.[14] Ranjit *et al.*[15] found a positive correlation between chronic stress and higher levels of IL-6 and CRP.

While present study indicated significant positive effects of aerobic continuous training programme on blood pressure, CRP and psychosocial status of men with hypertension; there are however, limitations of the study; including inability to objectively investigate the endothelia physiology, gender differences response to exercise training and lack of long time follow up. This limitations warrant attention in future studies.

Conclusions

The present study demonstrates a rationale bases for the role of continuous exercise training in the down regulation of blood pressure, CRP and psychosocial stress in the management of hypertension.

References

1. Derman EW, Whitesman S, Dreyer M, Patel DN, Nossel C, Schwellnus MP. Healthy lifestyle interventions in general practice Part 7: Lifestyle and hypertension. South Africa Fam Pract 2009;51:382-6.
2. Sliwa K, Wilkinson D, Hansen C, Ntyintyane L, Tibazarwa K, Becker A *et al.* Spectrum of heart disease and risk factors in a black urban population in South Africa (the Heart of Soweto Study): a cohort study. Lancet 2008;371:915-22
3. Kearney PM, Whelton M, Reynolds K, Muntner P, Whelton PK, He J. Global burden of hypertension: analysis of worldwide data. *Lancet* 2005;**365**:217-23.
4. Williams B, Poulter NR, Brown MJ, Davis M, McInnes GT, Potter JF. British Hypertension Society. Guidelines for management of hypertension: report of the fourth working party of the British Hypertension Society, 2004-BHS IV. *J Hum Hypertens* 2004;**18**:139-85.
5. Joint National Committee on Prevention, Evaluation and Treatment of high blood pressure. The fifth Report of the JNC on Detection, Evaluation and Treatment of High Blood Pressure (JNC). Arch Intern Med 1993;153:154-83.
6. Markovitz JH, Mathews KA, Kannel WB, Cobb JL, D'Agostino RB. Psychological predictors of hypertension in the Framingham study:is there tension in hypertension? JAMA 1993;270:2439-443.
7. Anderson E., Castelli WP, Levy D. Elevated sympathetic nerve activity in borderline hypertensive humans. Hypertension 1989;14:177-83.
8. Magnus M. Cardiovascular health among African Americans and intervention strategies. AMJ Health Promotion 1991;282-90.
9. Hakim AA, Petrovitch H, Burchfiel CM, Ross GW, Rodriguez BL, White LR *et al.* Effects of walking on mortality among nonsmoking retired men. N Engl J Med 1998;338:93-4.
10. Siegel W, Blumenthal J. The role of exercise in the prevention and treatment of hypertension. Ann Behav Med 1991;13:23-30.
11. Kriska AM, Blair SN, Pereira MA. The potential role of physical activity in the prevention of non-insulin dependent diabetes mellitus:the epidemiological evidence. Exerc Sport Sci Rev 1994;22:121-43.
12. Wood PD, Stefanick ML, Dreon DM, Frey-Hewitt B, Garay SC, Williams PT *et al.* Changes in plasma lipids and lipoproteins in overweight men during weight loss through dieting as compared with exercise. N Engl J Med 1988;319:1173-9.
13. Rozanski A, Blumenthal JA, Kaplan J. Impact of psychological factors on the pathogenesis of cardiovascular disease and implications for therapy. Circulation 1999;27:2192-217.
14. McDade TW, Hawkley LC, Cacioppo JT. Psychosocial and behavioral predictors of inflammation in middle-aged and older adults:The Chicago Health, Aging, and Social Relations Study. Psychosom Med 2006;68:376-81.
15. Ranjit N, Diez-Roux AV, Shea S, Cushman M, Seeman T, Jackson SA *et al.* Psychosocial factors and inflammation in the multi-ethnic study of atherosclerosis. Arch of Intern Med 2007;167:174-81.
16. Black P. Stress and the inflammatory response:A review of neurogenic inflammation. Brain Behav Immun 2002;16:622-53.
17. Crews DJ, Landers DM. A meta-analytic review of aerobic fitness and reactivity to psychosocial stressors. Med Sci Sports Exerc 1987;19:114-20.
18. Myers RH, Kiely DK, Cupples LA, Kannel WB. Parental history is an independent risk factor for CHD:The Framingham study Am Heart J 1990;120:963-9.
19. Cornelissen VA, Verheyden B, Aubert AE, Fagard RH. Effects of aerobic training intensity on resting, exercise and post-exercise blood pressure, heart rate and heart-rate variability. J Hum Hypertens 2009;24:175-82.
20. Laterza MC, Demator LD, Trombetta IC, Braza AM, Roveda F, Alves MJ *et al.* Exercise training restores baroreflex sensitivity in never trained hypertensive patients. Hypertension 2007;49:1298-306.
21. World Health Organization Expert Committee on hypertension control. Hypertension control. Geneva; 1996. p. 24-31.
22. Terry C, Loukaci V, Green FR. Cooperative influence of genetic polymorphisms on interleukin 6 transcription regulation. J Biol Chem 2000;275:18138-44.
23. Groove ML, Morrison A, Folson AR, Boerwinkle E, Hoelscher DM, Bray MS. Gene-environmenet interaction and the GNB3 gene in the atherosclerosis risk in community study. Int J Obes 2007;3:913-26.
24. Hagber JM, Farrell RE, Dengel DR, Wilund KR. Exercise training-induced blood pressure and plasma lipid improvements in hypertensive may be genotype dependent Hypertension 1999;34:18-23.
25. American College of Sport Medicine. Guide lines for exercise testing and Prescription. 4th Edition. Philadelphia: Lea & Febiger; 1991.
26. Townsend RR, Mcfadden TC, Ford V, Cadee JA. A randomized double blind, placebo-controlled trial of casein protein hydrolysnte (C12 peptide) in human essential hypertension. Am J Hypertension 2004;17:1056-8.
27. Musa DI. Ibrahim DM, Toriola AL. Cardiorespiratory fitness and risk factors of CHD in pre-adolescent Nigerian girls. J Human Movement Studies 2002;42:455-5.

28. International Society for the Advancement of Kinanthropometry (ISAK). International standards for anthropometric assessment. Patche Fstroom, South Africa: ISAK; 2001.
29. Ross WD, Marfell-Jones MJ. Physiological testing of the high performance athletes. In: MacDugall JD, Wenger A, Green HJ, editors. Kinanthropometry. Champaign IL: Human Kinetics Books; 1991. p. 223-308.
30. Bachorik PS. Collection of blood sample for lipoprotein analysis. Clin Chem 1982;28:1375-8.
31. Lamina S, OKoye CG, Dagogo TT. Erectile dysfunction management in hypertension:The role of continuous training programme on the biomarkers of inflammation. BJU Int 2008;103;1218-21.
32. Stephens T, Graig CL. The well being of Canadian:highlights of the 1988 Cambell Survey Offawa Canadian fitness and lifestyle Research Institute.1990.
33. American College of Sports Medicine. ASCM's guidelines for exercise testing and prescription 5th Edition. Baltimore: Williams & Wilkins; 1995.
34. Katzung BG. Basic and clinical pharmacology. 7th edition. New York: Lange Medical Books/Craw Hill; 1998.
35. Mancia G, Ferari L, Gregorini L, Leonett L, Terzoli L, Biachini C *et al.* Effects of treatment with methyldopia on basal haemodynamic and on rural control. In:Robertson JS, Pickering GW, Goldwell ADS, editors. The therapeutics of hypertension. London:Royal Society of Medicine and Academic Press Inc Ltd; 1980. p. 70-8.
36. Salako LA. Treatment of hypertension:cardiovascular disease in Africa. Ibadan: Ciba Geigy Ltd; 1976.
37. American College of Sport Medicine. Physical activity, physical fitness and hypertension. Med Sci Sports Exer 1993;25:i-x.
38. Westhoff TH, Franke N, Schmidt S, Valbracht-Israng K, Meissner R, Yildirim H *et al.* Too old benefit from sports? the cardiovascular effects of exercise training in elding subjects treated for isolated systolic hypertension. Kidney Blood Press Res 2007;30:240-7.
39. Smith PJ, Blumenthal JA, Babyk MA, Georgiades A, Hinderlister A, Sherwood A. Effects of exercise and weight loss on depressive symptoms among men and women with hypertensive. J Pschosome Res 2007;63:463-9.
40. Ulrik W, Asbjorn LP, Morten B, Qivird R, PerMagnus H, Erik TA *et al.* Superior cardiovascular effect of aerobic interval training versus moderate continuous training in heart failure patients. Circulation 2007;115:3086-94.
41. Klocek M, Kubinyi A, Bacior B, Kawecka-Jaszcz K. Effect of physical training on quality of life and oxygen consumption in patients with congestive heart failure. Int J Cardiol 2005;103:323-9.
42. Georgiades A, Sherwood A, Gullette ECD, Babyak MA, Hinderliter A, Waugh R *et al.* Effects of Exercise and Weight Loss on Mental Stress–Induced Cardiovascular Responses in Individuals With High Blood Pressure. *Hypertension* 2000;36:171-6.
43. Pierce, TW, Madden DJ, Siegel WC, Blumenthal JA. Effects of aerobic exercise on cognitive and psychosocial functioning in patients with mild hypertension. Health Psychology 1993;12:286-91.
44. Kohut ML, McCann DA, Russell DW, Konoplan DN, Cunnick JE, Frank WD *et al.* Aerobic exercise, but not flexibility/resistance, reduces serum IL-18, CRP and IL-6,independent of beta-blockers, BMI and psychosocial factor in older adults. Brain Behav Immun 2006;20:201-9.
45. Rubin RT. Pharmacoendocrinology of major depression. Eur Arch Psychiatry Neurol Sci 1989;238:259-67.
46. Droste SK, Gesing A, Ulbricht S, Muller MB, Linthorst AC, Reul JM. Effects of long-term voluntary exercise on the mouse hypothalmic-pituitary-adrenocortical axis. Endocrinology 2003;114:3012-23.
47. Dishman RK, Renner KJ, Youngstedt SD, Reigle TG, Bunnell BN, Burke KA *et al.* Activity wheel running reduces escape latency and alters brain monoamine levels after footshock. Brain Res Bull 1997;42:399-40.
48. Kullo DI, Khaleghi M, Hensrud DD. Markers of inflammation are inversely associated with VO_2max in asymptomatic men. J Appl Physiol 2007;102:1374-9.
49. Gallistl S, Sudi KM Aigner R, Borkenstein M. Changes in serum interleukin-6 concentrations in obese children and adolescents during a weight reduction program. Int J Obes 2001;25:1640-3.

Received on September 19. 2011.
Accepted for publication on June 22, 2012.

Received on September 19, 2011 - Accepted for publication on June 25, 2012.

Corresponding author: S. Lamina, Biomedical Technology Department School of Health Technology, Federal University of Technology, Owerri, Nigeria. E-mail: siklam_86@yahoo.co.uk

Are there differences in motor recovery between upper and lower limbs in hemiplegic patients with hemorrhagic stroke?

M. PACI [1], L. NANNETTI [1], S. MORETTI [2], E. BOCCALETTI [2], B. LOMBARDI [3]

[1]Department of Rehabilitation Medicine, Prato Hospital, Prato, Italy; [2]Prato Hospital, Prato, Italy; [3]Health Local Unit 4, Prato, Italy

ABSTRACT

Aim. The aim of this study was to compare the time course of upper limb (UL) and lower limb (LL) in a sample of patients who have had an hemorrhagic stroke.
Methods. Consecutive patients following hemorrhagic stroke were recruited in a rehabilitation ward and evaluated at admission, discharge and one month after discharge with the arm and leg motor parts of the Fugl-Meyer scale. Separate analyses were also performed for patients with severe and mild motor impairment.
Results. One hundred and three patients were included in the study, 72 in the “severe” group. No significant difference between time course of UL and LL motor recovery were found in the whole sample and in the two groups.
Conclusion. This study shows a similar motor recovery in UL and LL in patients who have had a hemorrhagic stroke. However, caution should be used in the utilization of results in the functional prognosis of limbs in a rehabilitation setting. *(it j physiotherapy 2012;2:59-64)*

Key words: Lower extremity - Outcome assessment - Stroke - Upper extremity.

Stroke is a highly heterogeneous disorder with distinct pattern of recovery and the detailed knowledge on the course of recovery is helpful in determining when to expect recovery and in targeting appropriate rehabilitation program.

Hemorrhagic strokes accounts for around 15-20% of all strokes and affects more than two million people worldwide each year.[1] A number of studies showed that patients with an intracerebral hemorrhage had more severe neurological and functional impairment in the acute phase, but a higher rate of recovery than patients with cerebral infarction.[2-4]

Few studies compared the patterns of recovery for upper (UL) and lower limbs (LL). In a classic anecdotal report, Twitchell [5] described the pattern of motor recovery following stroke. At onset, the UL was more involved than the LL, and eventual motor recovery in the UE was less than in the LE. More recently, Duncan *et al.*[6] reported similar patterns of motor recovery of extremities, using the Fugl-Meyer scale, in 95 patients with ischemic stroke. A further study conducted on 132 stroke patients showed no differences in terms of change in impairment, while results indicated a greater gain for lower extremities disability.[7] Also the results of the study by Higgins *et al.,*[8] performed on 55 stroke patients, indicated the similar recovery in UL and LL, measured in terms of impairment and activity limitation. A more recent investigation on time course of motor and functional performance after ischemic stroke showed comparable patterns of recovery for trunk, arm, leg, and functional performance.[9] All studies were performed on patients with ischemic strokes [6, 9] or in undifferentiated samples.[5, 7, 8] Despite recovery from hemorrhagic stroke may have distinctive course, no studies compared the specific recovery patterns of extremities after hemorrhagic stroke. The aim of this study was to compare the time course of UL and LL in a sample of patients who have had an hemorrhagic stroke.

Materials and Methods

Subjects

The study was performed in the Unit of Functional Recovery of a city hospital.

A sample of consecutive patients, admitted for stroke to the rehabilitation department was selected. They all met the following inclusion criteria: 1) first stroke; 2) monolateral hemorrhagic stroke determined by computer tomography scans or magnetic resonance imaging; 3) recent stroke (occurred within less than 30 days); 4) no neurosurgery treatments. Patients with additional musculoskeletal or neurological disabling impairments were excluded. A neurologist made the diagnosis of stroke.

Baseline demographic characteristics included age, sex, and clinic characteristics, including length of stay in hospital, time from stroke onset, impairment at admission and side of lesion were recorded.

Outcome measures

In order to assess motor recovery of UL and LL, the two sections of the Fugl-Meyer Scale (FM) [10] were used. The FM is a multi-item scale which evaluates balance and motricity, sensation, range of joint motion and pain in the paretic arms. The items of the assessment are scored on a three-point rating scale: 0=unable to perform, 1=partial ability to perform, and 2=near normal ability to perform.[10] The excellent psychometric characteristics of the FM are well established.[11, 12] For this study the motricity subscore of lower and upper extremity parts of the scale was used in order to assess the motor recovery. These parts have been shown to have excellent intra-rater reliability and high inter-rater reliability.[13]

All the assessments were performed by staff physiotherapists, with 4 to 15 years of experience with stroke patients. Outcome measurements were performed at admission to department (T1), at discharge (T2), and at follow up (T3). Follow-up assessment was performed about 30 days from discharge. Measurements were administered by physiotherapists in a random order, and not necessarily the same rater assess the same patient.

Treatment

All patients were treated, during hospitalization in the rehabilitation department, with individual physiotherapy twice a day (3 hours) for five days a week and a single 1 hour session for two days a week (on Saturday and Sunday).

From discharge to follow-up, all patients were treated in outpatient centers of the Hospital's Unit of Rehabilitation in the same Local Health Service on 2 to 3 days a week with one-hour sessions. Physiotherapy intervention was based on a mix of components from different approaches [14] and, in any case, on the need of each subject evaluated by a physiotherapist. Occupational therapy, speech therapy and neuropsychological training were administered according to individual needs.

Statistical analysis

To place the upper and lower extremity data in the same scale, the FM motor scores were divided by the total possible score for that extremity (66 for UL, 34 for LL), obtaining a percentage of the FM motor score.

To determine whether the patterns of recovery for the UL and LL varied depending on the initial impairment, patients were divided into two groups based on their baseline FM motor scores, as described by Duncan *et al.*:[6] 0 to 55, severe to moderately severe impairment (severe group); 56 or greater, moderate or mild impairment (mild group). Different analyses were performed separately by stratum.

An analysis of variance (ANOVA) for repeated measures was used to explore if there was a

Table I.—*Patients' demographic and clinical characteristics.*

Variable	Severe	Mild	p value	Total
No. of patients	72	31		103
Age, years (mean, SD)	64.9±13.6	70.6±9.5	0.04	66.6±12.7
Male sex, N. (%)	48	15	n.s.	63 (61.2)
Time from stroke onset (days) (M±SD)	17.6±9.4	18.3±8.4	n.s.	17.8±8.3
Length of stay (days) (M±SD)	39.4±14.5	19.9±9.1	<0.001	33.6±15.9
Hemisphere of stroke (right), N. (%)	38	19	n.s.	66 (67.1)
Fugl-Meyer Motor score at T1	13.6±14.2	75.3±10.0	<0.001	32.2±31.3

M: mean; SD: standard deviation.

difference between limb recovery at each phase of assessment. Analyses were performed on the whole sample and separately by group.

The level of statistical significance was set at 0.05. Data analyses were performed using the SPSS statistical package 13.0 for Windows.

Results

One-hundred-eighteen patients with hemorrhagic stroke were admitted in the rehabilitation department. Of those, 11 were excluded because they had undergone surgical treatment, and 4 have had previous stroke.

A final number of 103 patients with hemorrhagic stroke, 63 (61.2%) men, mean age of 66.6±12.7 years was included in the study. All suffered from intraparenchymal hemorrhage. Seventy-two patients were classified as having severe stroke and 31 were included in the "mild" group. Table I provides the demographic and clinical characteristics of the patients assessed. Patients in the severe group were older (P=0.04) and had a longer length of stay in the rehabilitation department, when compared to those in the "mild" group (P<0.001). No differences were found for time from stroke onset, hemisphere of stroke and gender. The percentage of the UL and LL FM motor score at T1 were not different for the severe group, mild group and for the whole sample.

Measures of motor recovery showed a significant improvement over time for both UL and LL (P<0.001) for all the analyses. No significant differences between UL and LL were found by the analyses in the whole sample (Figure 1), the severe group (Figure 2) and the mild group (Figure 3).

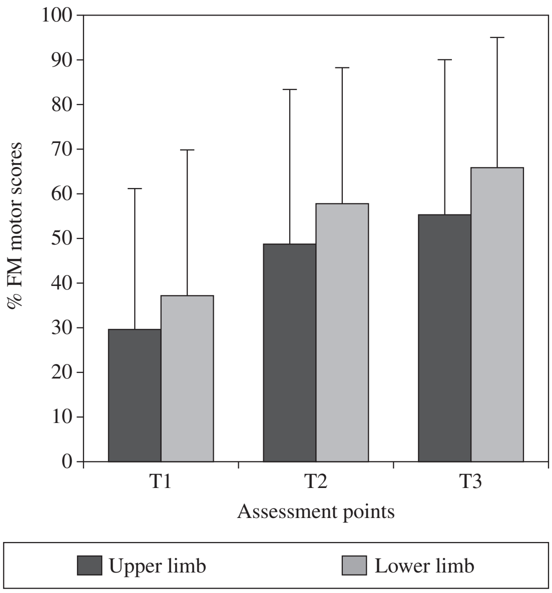

Figure 1.—Comparison of upper and lower limb Fugl-Meyer motor score in the whole sample (mean ± standard deviation).

Discussion

This study compares the recovery of UL and LL in hemiplegic patients within the first three months after their hemorrhagic stroke. All patients show a significant improvement in motor recovery.

This finding is not surprising, because the improvement of motor recovery occurs more rapidly within the first months for stroke for both UL and LL.[6, 7, 9] In addition, several studies show that patients with hemorrhagic stroke have greater functional improvement than cerebral infarction patients of similar severity at baseline.[3, 4, 15] In fact, the faster and greater functional recovery of patients with hemorrhagic stroke when

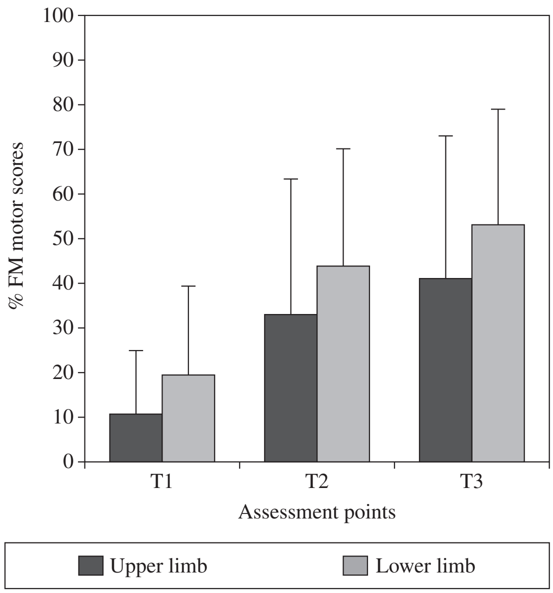

Figure 2.—Comparison of upper and lower limb Fugl-Meyer motor score in the "severe" group (mean ± standard deviation).

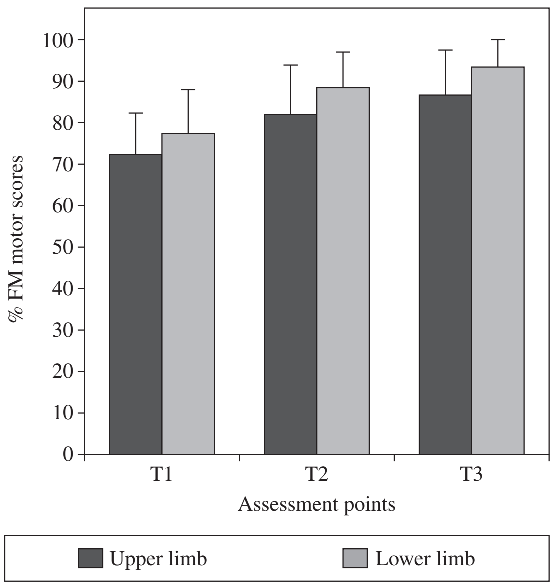

Figure 3.—Comparison of upper and lower limb Fugl-Meyer motor score in the "mild" group (mean ± standard deviation).

compared to those with ischemic stroke may be explained by the reduction or the resolution of the hematoma size, with a restoration of part of the brain tissue function.[3, 15]

Patients were analysed as a whole sample and stratified according to the severity of motor impairment at admission as proposed by Duncan *et al.*[6] These authors suggest a stratification in four categories (very severe, severe, moderate, mild), but, given the relative small sample of our study, we choose to use the cut-off score that divides patients with very severe and severe inpairment ("severe" group) from those with moderate and mild impairment ("mild" group).

At admission, no significant differences were observed between UL and LL percentage of the FM motor score in all groups, in contrast to observations by Desrosiers *et al.*,[7] that reported a lower level of motor function for UL than LL at baseline. However, the study did not report measures of variability and results were not statistically analysed. As showed in the figures, LL performance scored relatively higher compared to UL performance on the whole study period, but a high variability can also be observed and considered when compare scores.

The results of this study also show no differences in patterns of recovery in UL and LL in patients with hemorrhagic stroke, confirming the results of several other investigations performed on ischemic stroke or undifferentiated samples.[5-9] These findings seems to not support the general belief among rehabilitation professionals that the LL motricity recovers faster and more completely than the UL motricity.[6]

However, between 55% and 75% of survivors continue to experience upper extremity functional limitations,[16] which are associated with diminished health-related quality of life,[17] even 3 to 6 months later.[18] According to Kwakkel *et al.*,[19] most stroke survivors regain the ability to walk, whereas only between 30% and 66% of stroke survivors are able to use their affected arm. Moreover, limitations in the use of the UL have been shown to greatly contribute to diminished self-reported well-being one year following a stroke.[20]

These conflicting findings are reasonably due to the level of measurement. In fact, the most important limitation for patients after a stroke seems to be the functional use of the UL, at an activity level, while the FM assesses the motor impairment. Then, we can argue that, with similar impairment, the LL can provide more satisfactory functional performances, such as walking. On the contrary, more demanding performances is required to the UL in terms of dexterity, precision and coordination, and therefore the performances appear less satisfactory than the LL with similar impairment. For example, a large cohort study determined that six months after stroke, 65% of persons with an average Barthel Index (BI) score of 90 of 100 could not incorporate the paretic arm into life activities.[21] Moreover, other impairments, such as post-stroke depression,[22] shoulder pain [23] muscle tone, cognitive and neuropsychological disorders [24] have been shown to have a negative impact on motor and/or functional recovery.

Two studies were aimed to compare UL and LL in terms of both impairment and disability changes. Higgins *et al.*[8] compared the functional performances of UL and LL using measures of activity limitation (Box and Block Test/Frenchay Arm Test and 5-meter walk test/Timed "Up and Go" test, respectively) in a sample of 55 patients with both ischemic and hemorrhagic strokes. Also this study reports no differences between arm and leg both in impairment and activity measures. Desrosiers *et al.*[7] also found no differences in terms of impairment recovery, measured by FM, while LL had a faster recovery in terms of disability measures when compared to UL (T*est Evaluant la Performance des Membres superieurs de Personnes Agees* for UL and Berg Balance scale, walking speed and walking endurance for LL).

However, since the used outcome measures seems to be difficult to compare, given their different construct and levels of measurements, measures of motor impairment, based on the same construct and using the same grading, seem to be the most appropriate for a comparison.

Some potential limitation should be considered in the interpretation of the results**.** First, the sample is not large, although the number of patients is similar to previous studies on ischemic or undifferentiated strokes [6, 7] or even larger.[8, 9] However, considering that the hemorrhagic strokes account for 15-20% of all strokes, this can be considered the larger sample on which the UL and LL recovery has been studied. In addition, this was not a population-based study; therefore, not all stroke survivors were included and results should be generalized only for patients in an inpatient rehabilitation setting.

Since the achievement of motor recovery is a variable which can influenced the choice for a discharge, the use of admission/discharge assessment might have introduced some bias. It is possible that people with faster recovery might have been discharged in a shorter time and consequently assessed at an earlier point in the recovery period. However, this bias should not have influenced the results, since we found no differences between the two groups in the interval between each phase of assessment and stroke onset.

In conclusion, this study shows a similar motor recovery in UL and LL in patients who have had a hemorrhagic stroke. However, caution should be used in the utilization of our results in the functional prognosis of limbs in a rehabilitation setting.

References

1. Qureshi AI, Mendelow AD, Hanley DF. Intracerebral haemorrhage. Lancet 2009;373:1632–44.
2. Chae J, Zorowitz RD, Johnston MV. Functional outcome of hemorrhagic and nonhemorrhagic stroke patients after in-patients rehabilitation: A Matched Comparison. Am J Phys Med Rehabil 1996;75**:**177-82.
3. Kelly PJ, Furie KL, Shafqat S, Rallis N, Chang Y, Stein J. Functional recovery following rehabilitation after hemorrhagic and ischemic stroke. Arch Phys Med Rehabil 2003;84:968-72.
4. Paolucci S, Antonucci G, Grasso MG, Bragoni M, Coiro P, De Angelis D *et al.* Functional outcome of ischemic and hemorrhagic stroke patients after inpatient rehabilitation: a matched comparison. Stroke 2003;34:2861-5.
5. Twitchell TE. The restoration of motor function following hemiplegia in man. Brain 1951;74:443-80.
6. Duncan PW, Goldstein LB, Horner RD, Landsman PB, Samsa GP, Matchar DB. Similar motor recovery of upper and lower extremities after stroke. Stroke 1994;25:1181-8.
7. Desrosiers J, Maouin F, Richards C, Bourbonnais D, Rochette A, Bravo G. Comparison of changes in upper and lower extremity impairments and disabilities after stroke. Int J Rehabil Res 2003;26:109-16.
8. Higgins J, Mayo NE, Desrosiers J, Salbach NM, Ahmed S. Upper-limb function and recovery in the acute phase post-stroke J Rehabil Res Dev 2005;42:65-76.
9. Verheyden G, Nieuwboer A, De Wit L, Thijs V, Dobbelaere J, Devos H *et al.* Time course of trunk, arm, leg, and functional recovery after ischemic stroke. Neurorehabil Neural Repair 2008;22:173-9.
10. Fugl-Meyer AR, Jääskö L, Leyman I, Olsson S, Steglind S. The post-stroke hemiplegic patient, I: a method for evaluation of physical performance. Scand J Rehabil Med. 1975;7:13-31.
11. Salter K, Jutai JW, Teasell R, Foley NC, Bitensky J. Issues for selection of outcome measures in stroke rehabilitation: ICF body functions. Disabil Rehabil. 2005;27:191-207.

12. Gladstone DJ, Danells CJ, Black SE. The Fugl-Meyer Assessment of motor recovery after stroke: A critical review of its measurement properties. Neurorehabil Neural Repair 2002;16:232-40.
13. Duncan PW, Propst M, Nelson SG. Reliability of the Fugl-Meyer assessment of sensorimotor recovery following cerebrovascular accident. Phys Ther 1983;63:1606-10.
14. Pollock A, Baer G, Pomeroy V, Langhorne P. Physiotherapy treatment approaches for the recovery of postural control and lower limb function following stroke. Cochrane Database of Systematic Reviews 2007;1.
15. Schepers VP, Ketelaar M, Visser-Meily AJ, de Groot V, Twisk JW, Lindeman E. Functional recovery differs between ischaemic and hemorrhagic stroke patients. J Rehabil Med 2008;40:487-9.
16. Nakayama H, Jørgensen HS, Raaschou HO, Olsen TS. Compensation in recovery of upper extremity function after stroke: the Copenhagen stroke study. Arch Phys Med Rehabil 1994;75:852-7.
17. Nichols-Larsen DS, Clark PC, Zeringue A, Greenspan A, Blanton S. Factors influencing stroke survivors' quality of life during subacute recovery. Stroke 2005;36:1480-4.
18. Lai SM, Studenski S, Duncan PW, Perera S. Persisting consequences of stroke measured by the Stroke Impact Scale. Stroke 2002;33:1840-4.
19. Kwakkel G, Kollen BJ, Wagenaar RC. Therapy impact on functional recovery in stroke rehabilitation: a critical review of the literature. Physiotherapy 1999;13:457-70.
20. Wyller TB, Sveen V, Sodring KM, Pettersen AM, Bautz-Holter E. Subjective well-being one year after stroke. Clin Rehabil 1997;11:139-45.
21. Mayo NE, Wood-Dauphinee S, Côté R, Durcan L, Carlton J. Activity, participation, and quality of life 6 months post-stroke. Arch Phys Med Rehabil 2002;83:1035-42.
22. Nannetti L, Paci M, Pasquini J, Lombardi B, Taiti PG. Motor and functional recovery in patients with post-stroke depression. Disabil Rehabil 2005;27:170-5.
23. Lindgren I, Jönsson A-C, Norrving B, Lindgren A. Shoulder pain after stroke: a prospective population-based study. Stroke 2007;38:343-8.
24. Feys H, De Weerdt W, Nuyens G, Van De Winckel A, Selz B, Kiekens C. Predicting motor recovery of the upper limb after stroke rehabilitation: value of a clinical examination. Physiother Res Int 2000;5:1-18.

Received on April 16, 2012 - Accepted for publication on June 25, 2012.

Corresponding author: M. Paci, Department of Rehabilitation Medicine, Prato Hospital, Prato, Italy. E-mail: matteo.paci@sif-fisioterapia.it

Surface electromyography pattern of masseter, orbicularis oris and submental muscles during swallowing of different consistencies in healthy subjects

G. CORTI [1], A. GHIGGI [2], M. MURELLI [3], A. TETTAMANTI [1]

[1]Università Vita-Salute,San Raffaele Hospital, Milan, Italy; [2]Moriggia-Pelascini Hospital, Gravedona, Como, Italy; [3]Vizzolo Predabissi Hospital, Vizzolo Predabissi, Milan, Italy

ABSTRACT

Aim. Surface electromyography (sEMG) studies on swallowing have not yet reached clear and standardized patterns regarding duration and intensity of EMG activation. Record of intensity data are mainly based on absolute mvolts values, with possible biases related to electrodes positioning, cross talk and skin impedance. The objective of the study was to investigate sequence, duration and the intensity of sEMG activation of masseter, orbicularis oris and submental muscles in 25 adult healthy subjects during swallowing of four different bolus: saliva, water, semi-liquid, and solid.

Methods. Time recording was done by visual assessment of the sEMG curve, while the intensity was measured as percentage of maximal activation of the respective muscle. Statistical analysis included analysis of variance with contrasts of the three muscles for the four consistencies.

Results. sEMG duration of orbicularis oris and submental muscles' increase with bolus viscosity; orbicularis oris is the first muscle activating and the sequence varies across consistencies; sEMG intensity of masseter and submental muscles increases together with viscosity whereas orbicularis oris' together with volume.

Conclusion. The study confirmed the role of three key muscles groups during swallowing in relation to bolus characteristics. sEMG intensity as percentage of maximal activation could be a valid procedure for overcoming biases due to electrodes positioning. Future studies in people with deglutition disorders could apply this sEMG method for assessing appropriate bolus consistencies in relation to one or more dysfunction of the considered muscles.*(it j physiotherapy 2012;2:65-73)*

Key words: Deglutition - Electromyography - Deglutition disorders.

In recent years surface electromyography (sEMG) methodology has seen a growing application for the evaluation and treatment of dysphagia. Various studies investigated the behaviour of the main muscles involved in the swallowing event, reporting relevant data on timing, duration, intensity and curve pattern of EMG muscle activation, both on healthy subjects and subjects with swallowing disorders.[1-24] Some authors explored the correlation of sEMG activity with swallowing events through the use of videofluoroscopy;[1, 13, 15] others studied the variation of sEMG activity while swallowing food of different consistency,[5, 6, 8, 10, 14, 16] volume,[8, 10, 13, 14, 16] and taste,[9, 17] while others again studied the variation of EMG activity in relation to the posture of the subject,[13, 16, 18, 24] or to various thermal, taste, mechanical, and visual stimuli submitted to the subjects.[19, 20]

All this works provided useful information for understanding the physiological and pathological mechanism of swallowing. The main muscles took in consideration by sEMG studies are the submental, the orbicularis oris and the masseter, as among all muscles involved in the swallowing event, they are the ones more easily accessible by sEMG, and playing a key role in the process. The submental muscles involved with swallowing are the geniohyoid, the digastric anterior and the mylohyoid muscles,[6] and their activation is correlated with the upwards and forward movement of the hyoid bone, and then with laryngeal elevation.[1, 21] The orbicularis oris instead plays a key role in containing the bolus in the mouth from the front side, while the masseter is involved, in synergy with laryngeal elevation, in stabilizing the mandible bone in favour of the submental muscles.[4, 22, 23]

For what concern the durational aspect, the length of swallowing according to sEMG activation ranges between 0.7 and 5 s, depending on the different muscles activity taken as starting and ending point, and on the type and volume of bolus taken. Some works in fact consider the end of orbicularis oris activation as the starting point and the end of the infrahyoid muscles activation as the ending point,[2] while others consider just the beginning and ending of submental muscles activation.[5, 8, 19] All studies concordantly report that the duration of swallowing increases together with increase of both volume and viscosity of bolus. Together with duration of activation, some works analysed the sequence of muscle activation among the key muscles,[5, 10, 24] and tried to identify some common patterns, which resulted anyway not always similar among different studies.

Looking at the intensity of activation, it is possible to notice how the submental muscles have a higher sEMG activity with thick solid food (cheese, peanut butter), compared to more liquid substances,[10] and similarly a higher activity with saliva compared to water.[8]

Although the studies carried out so far provided some interesting trends of sEMG activity during swallowing, a clear and standardized pattern of EMG activity which could have clinical utility is still to be achieved for various reasons: firstly, the results, both regarding the duration and the intensity of activation, are still different among the studies; even Vaiman's study,[2-4] which included 440 patients and tried to set a database on swallowing patterns, showed a great variability both within the same subject and among subjects. Secondly, regarding the intensity of activation it is dutiful noticing how with surface electromyography there are methodological shortcomings related to electrodes positioning, cross talk, skin impedance, which weakens the results based on absolute mvolts values.

Taking this in consideration, and with the aim of contributing to define better this field of research, this work intended to study sequence, duration and the intensity of sEMG activation of masseter, orbicularis oris and submental muscles during swallowing in adult healthy subjects. Time recording was done by visual assessment of the sEMG curve, while the intensity data were normalised computing the activation of the respective muscle during maximal isometric contraction as proposed by Knutson [25, 26] for sEMG studies, in order to overcome the biases due to electrodes positioning.

Materials and methods

Subjects

Twenty-five healthy subjects participated in this study. Recruitment was done among students of the first and second year of the degree course in physiotherapy of Vita-Salute San Raffaele University of Milan. Age ranged between 18 and 25 years, while gender distribution was of ten males and fifteen females. All participants signed a consent form after being informed about the general purpose of the study. Although being physiotherapy students, they had not yet attended specific lessons on deglutition physiology and disorders.

Surface electromyography measurements

The study recorded the sEMG activity of orbicularis oris, masseter and submental muscles during four voluntary single swallowing conditions: saliva, ten cc of water, 10 cc of semi-liquid bolus (homogenised fruit) and 4 g of solid bolus (loaf bread). Electrodes positioning made reference to previous sEMG studies and to anatomical correlation studies;[4, 6, 13, 20, 27, 28] assuming that in healthy subjects the muscle activation

Figure 1.—Positioning of sEMG electrodes respectively for masseter, orbicular oris and submental muscles

for swallowing is the same in the two sides of the body, the study decided to consider only the right one. Pairs of standard bipolar electrodes were positioned as follows (Figure 1): two electrodes posed parallel to the right masseter's fibers, identified by a voluntary elevation of the mandible; two electrodes posed at the right angle of the mouth, one just above and one just below the lip rime; two electrodes posed on the mental floor, just right to the medial line and within the mandible ridge, parallel to medial line. For masseter and submental muscles the distance between the electrodes was 2 cm, while for orbicularis oris was 2.5 cm. A single ground electrode was also positioned on the distal epiphysis of ulna. Prior to electrodes attachment, the skin was accurately cleaned with paste in order to reduce skin impedance. sEMG record made use of an 8 channel Telemg BTS (Milan) with pre-amplification and wireless transmission from the subject to the receiver station; acquisition frequency was set at 1000 Hz, while low and high pass filter from 50 to 250 Hz.

Once the electrodes were placed, the subjects underwent two consecutive sets of measurement, the sEMG intensity during maximal isometric contraction for each muscle group and four series of swallowing trials. For the maximal isometric contraction, subject were lying on a bed with a 4 cm rigid pillow under their head, and performed the following three tasks: 1) maximal isometric mandible elevation, with dental arches pushing one against the other for masseter muscle; 2) maximal inspiration followed by a maximal expiration keeping the mouth closed for orbicularis oris; 3) maximal isometric opening of the mouth against manual resistance by the operator for submental muscles. Each task lasted three seconds and was performed three times with one minute rest in between. Prior to the trials subjects were trained for about 10 minutes on the gestures to be performed. The maximal isometric contractions just described were necessary for normalizing intensity data as previously stated. As can be noted, the gestures chosen for these contraction, while involving the same muscles, do not trace the same movements occurring during swallowing. This because the study wanted to respond to methodological issues recommended by the literature [26] for a correct performance of maximal activation: the execution of an isometric contraction and the choice of a simple standardized gesture the subject can easily repeat expressing the maximal force. The above muscles are involved in various gestures such as swallowing, phonation, respiration, chewing, anterior flexion of head, and the study identified the gesture which resulted more suitable for those methodological criteria.

For the swallowing trials the subjects were instead seated on a chair with high backrest, head in horizontal position not in contact with the chair, arms leaning on armrests, and looking at a point in front of them for keeping firm the head horizontally. From this position they had to perform single swallows on command of the operator who pronounced "ready?" and then "go!". Trials were done three times with saliva, ten cc of water, 10 cc of semi-liquid bolus and 4 g of solid bolus, with 30 seconds rest between each swallow. In the last condition, before giving the command "go", the volunteer was allowed to masticate the bread and to prepare for swallowing as soon as he/she felt the bolus was ready.

Statistical analysis

For maximal intensity measurement of each muscles group, the raw signal was first rectified, and then the mean intensity in mvolts of a central window of two seconds within the three seconds trial was computed: the highest value among the three trial was considered.

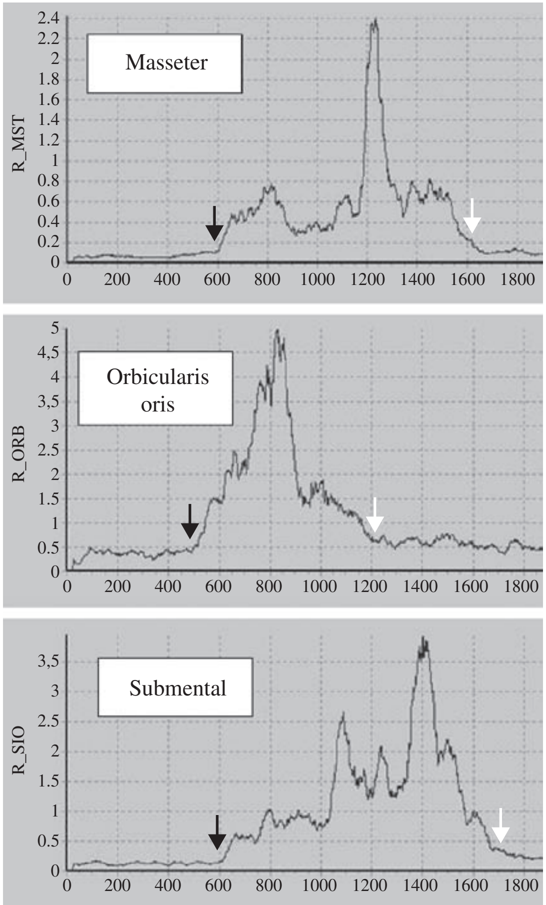

Figure 2.—Visual assessment of sEMG duration of activation for masseter, orbicularis oris and submental muscles. The signal has been filtered (50-250 Hz), rectified and integrated at 50 ms. X axis reports the time in milliseconds, Y axis the intensity of activation in mv. The beginning and ending of activation for each muscles is identified by the rapid change of curve inclination and indicated respectively by the black and grey arrows.

For the analysis of the swallowing trials, the study initially computed the time parameters in ms for each muscle group through a visual assessment of the sEMG curve (Figure 2). In order to do this the signal was first rectified and integrated at 50 ms., and then two operator concordantly identified the starting and ending point of the muscle activity. In case of discordance a third operator was involved. In this way it was possible to define both the time interval among the onset activation of each muscle and the duration of activation of each muscle. Concomitantly, in the same manner, also the total duration of the swallowing was computed by considering the first muscle activating and the last one switching off.

In a second time, the raw intensity for each muscle was computed by considering the mean value of the activation interval previously identified; these values were then normalised in percentages of the maximal activation of the respective muscle.

The statistical analysis made use of SPSS 13.0 program, and considered ms raw values for studying the duration of activation and the percentage of maximal activation values for studying the intensity of activation. The analysis included the following tests: the Kolmogoro-Smirnow test for checking the normality of the raw values, the analysis of variance for comparing the three trials of each swallowing task, the analysis of variance with contrasts for studying the interaction between muscles and food consistency. Due to the number of possible comparisons, the significance level was adjusted with Bonferroni correction to 0.01.

Results

Each one of the 25 volunteers performed 12 swallowing trials, 3 for each one of the four food consistencies. Among the 300 total trials, 54 were discarded, because of the difficulty in establishing a precise visual assessment, or because of acquisition artefacts due to electrodes small movements.

The analysis was therefore performed on the remaining 246 trials. The analysis of variance for repeated measures did non find significant differences ($P<0.05$) among the three trials for each consistency, both for time and for intensity data, and therefore the mean values were computed. Anyway, for all the parameters considered the results showed a great inter and intra-subject variability. Table I reports the descriptive results of duration for each food consistency for a total of 16 group of values: column 1 to 3 refers to single muscles activity, while column 4 refers to the total time of swallowing. In general all values reported a positive skewness, and four of them had also a significant P values (<0,05) at the Kolmogorov-Smirnov normality test. Therefore, in order to perform more correctly further analyses,

Table I.—*Duration of sEMG muscle activation in the four consistencies in msec; a-c) refers to single muscles; d) refers to the total swallowing event, from the start of the first muscle to the end of the last one, despite of sequence*

		Masseter (a)	Orbicularis oris (b)	Submental (c)	Total duration (d)
Saliva	mean	973	1099	1050	1276
	SD	291	379	316	334
	Median	916	1031	1025	1213
	P	0.200	0.010	0.200	0.123
Water	Mean	943	860	935	1220
	SD	185	310	229	279
	Median	931	813	927	1171
	P	0.200	0.150	0.200	0.000
Semi liquid	Mean	1082	1120	1111	1400
	SD	346	422	371	412
	Median	1030	1044	1023	1293
	P	0.023	0.200	0.177	0.017
Solid	Mean	1055	1149	1326	1493
	SD	299	296	294	247
	Median	1010	1164	1352	1442
	P	0.200	0.200	0.200	0.200

the Log10 for each mean value was computed. Figure 3 reports the mean duration among the four consistencies: 1) masseter's duration of activation does not vary across the four consistencies; 2) orbicularis oris has got the shortest duration with water, but this is significant only in comparison with semi-liquid (P=0.010) and solid (P=0.001); 3) the duration of submental muscles is significantly higher with solid than water (P=0.0001), saliva (P=0.009) and semi-liquid (P=0.007). Considering the total duration in the four consistencies, only between water and solid emerges a significant difference of total duration (P=0.001), with solid lasting longer then water. Looking at the difference of duration of the three muscles within the same consistency emerges the following: both for water and semi-liquid there is no significant difference; with saliva there is instead a significant difference (P=0.006) between masseter and submental muscles, whose duration is longer; with solid food the duration of submental muscles is significantly higher then masseter (P=0.0001) and orbicularis oris (P=0.004). Figure 4 shows the mean delay of onset among muscles in the four different consistencies. In all the conditions the orbicolaris oris appears as the first to activate (time 0). With saliva and solid, submental muscles are the second ones to activate, followed by masseter, while with water and semi-liquid masseter is the second and submental the third. Anyway the analysis of variance reports as significant (P=0.01) only the delay of masseter over orbicolaris oris for saliva and solid, and the delay of submental muscles over orbicularis oris for water and semiliquid. Moreover, the analysis of variance across consistencies showed a greater delay of masseter onset over submental onset with solid bolus (P=0.003) compared to other consistencies.

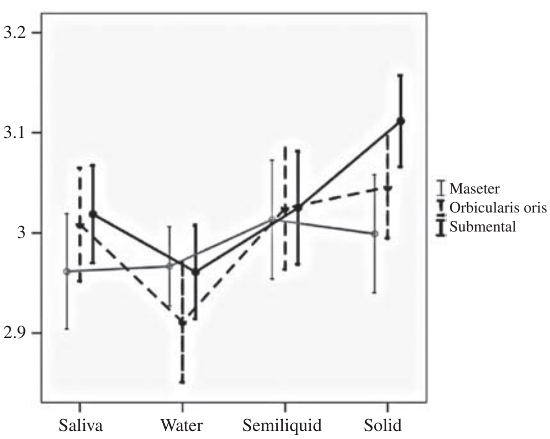

Figure 3.—Analysis of variance of swallowing duration of each muscle in the four consistencies. X axis reports the four different bolus consistencies. Y axis reports the Log10 values of mean duration in ms.

Table II reports the descriptive results regard-

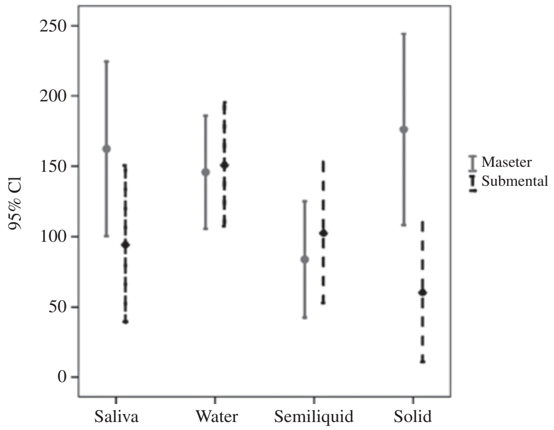

Figure 4.—Sequence of onset activation of the three muscles in the four consistencies. X axis reports the four different bolus consistencies. Y axis reports the mean value of onset delay between each respective muscle in milliseconds, obtained by the analysis of variance. The first muscle activating (orbicularis oris) was set at time 0 and the others to the respective mean delay values.

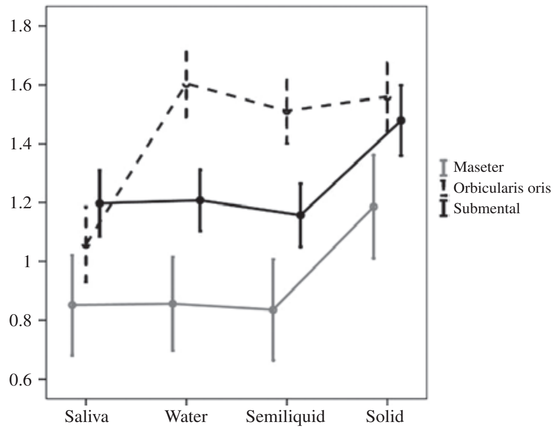

Figure 5.—Analysis of variance of sEMG intensity among the four consistencies for each muscle. X axis reports the four different bolus consistencies. Y axis reports the Log10 values of mean intensity. Intensity is computed as percentage of the maximal activation obtained for the same muscle.

ing intensity of activation for each muscles group in the four consistencies, expressed as percentage of the maximal activation value: also in this case data were not always normally distributed and a logarithmic (Log10) transformation was therefore applied in order to perform more correctly further analysis. Figure 5 reports the variation of intensity of each muscle in the four consistencies: 1) masseter's intensity does not vary significantly comparing water, saliva and semi-liquid, but is instead significantly higher (P=0.0001) with solid in comparison with the other three conditions; 2) the intensity of orbicularis oris does not differ significantly comparing water, semiliquid and solid, whereas it is significantly lower (0.0001) with saliva in comparison with the other three conditions; 3) the intensity of submental muscles is significantly higher (P=0.0001) with solid food in comparison with the other three consistencies. Considering the difference of activation intensity of the three muscles within the same consistency is possible to notice the fol-

Table II.—*Intensity of sEMG muscle activation in the four consistencies, expressed as percentage of maximal activation.*

		Masseter	Orbicularis oris	Submental
Saliva	Mean	9.90	13.99	18.32
	SD	9.74	10.50	12.07
	Median	7.08	9.16	15.29
	P	0.000	0.002	0.002
Water	Mean	10.20	47.26	18.75
	SD	9.19	25.26	10.71
	Median	6.92	46.25	15.95
	P	0.007	0.200	0.128
Semi liquid	Mean	10.28	38.28	17.56
	SD	11.60	23.37	10.61
	Median	5.20	33.71	15.81
	P	0.000	0.200	0.051
Solid	Mean	22.54	42.58	38.48
	SD	25.10	22.50	28.19
	Median	13.79	46.58	29.51
	P	0.000	0.200	0.001

lowing: masseter's intensity is significantly lower then the other two muscles in all the four conditions ($P<0.01$); orbicularis oris and submental muscles show similar intensity of activation with saliva and solid, whereas with water and semi-liquid the intensity of orbicularis oris is higher ($P=0.0001$) then submental muscles.

Discussion

The present work aimed at studying duration and intensity of sEMG activity of orbicularis oris, masseter and submental muscles during the swallowing of four different consistencies, namely saliva, water, semi-liquid and solid food in healthy subjects.

Concordantly with previous studies,[2-4, 22] the results report, both for time and intensity data of activation, a great inter subject and intrasubject variability.

Duration parameters are quite close to other studies, and the differences may be due to the starting and ending points taken in consideration: in our work the total swallowing duration ranges from 1220±279 ms for water to 1493±200 ms for solid; the majority of studies [5, 8, 19, 24, 29] report durations ranging between 700 and 1000 ms, considering just the activity of the submental muscles. Reimesrs-Neils *et al.*[10] consider both submental and infrahyoid muscles with values between 1200 and 1400 ms; Vaiman *et al.*[2] consider swallowing duration from the end of the oral phase to the beginning of the oesophageal phase, and report longer values ranging from 1000 to 5400 ms.

Regarding the sequence of activation our study reported similar results to Ding *et al.*'s study,[24] with orbicularis oris as the first muscle to activate and a variability in the continuing the sequence, with submental and masseter alternatively being the second. However, our work analysed data referring to subjects and not to the total number of swallows, conserving possible individual patterns, and yet studying variation across consistencies. Reimers-Neils *et al.*[10] analysed the variation of sequence across different consistencies too, but did not include masseter and orbicularis oris muscles.

Concerning intensity of activation, this study explored the possibility of computing not the real electromyography value in millivolts but the percentage of maximal activation, in order to avoid biases due to electrodes positioning. This procedure appears to be valuable as, despite the impossibility of confronting mean values with other studies because of different order of measures, some important result of the analysis of variance are comparable to the findings of other works.

In the end, although the already mentioned variability did not allow to obtain precise normative data on time and intensity of activation, the study provided as well, through the analysis of variance for muscles and consistencies, interesting information which contribute in understanding the role of each muscle, and may have clinical relevance if applied to people with swallowing disorders.

First of all it is possible to notice how, similarly to the total swallowing event, the duration of activation of the single muscle groups increases together with the viscosity of food, with water reporting the shortest duration, and solid the longest one. However this refers mainly to orbicularis oris and submental muscles, while masseter's duration does not vary significantly along consistencies. This is related also with the sequence of activation as with solid there is a significant ($P=0.003$) delay of masseter over submental onset compared to the other consistencies. All this is coherent with to the different roles of each muscles: submental muscles are involved both in stabilizing the hyoid bone when the tongue squeezes the bolus against the palate and, right after this, in elevating the hyoid bone during the swallow reflex: the total duration of this process is longer with high viscosity food as it is slower to be pushed. Concomitantly with these events, the orbicularis oris has to contain the bolus from the front side, varying its duration accordingly. Masseter's role is instead to stabilize the mandible and allow the elevation of the hyoid bone during the swallowing reflex: its duration is therefore similar with all consistencies as it does not activate during the pushing phase of swallowing, and the variation of duration in the reflex phase among different consistencies is very small. Regarding the intensity of activation, the results show a different behaviour of the three muscles groups in the four consistencies: masseter and submental muscles have a similar trend, varying their action in function of viscosity, as in both muscles there is a significant difference between solid and the other consistencies, with solid requiring a higher intensity. This is because, like other studies [4, 22, 23] have affirmed, the masseter fix the mandible during the hyoid elevation produced by the submental muscles.

Orbicularis oris instead seems to vary its activity in function of volume, as its intensity is significantly less during the swallowing of saliva compared to the three food consistencies: even if our study did not assess the swallowing of different volumes for the same consistency, it is possible to assume that with saliva the volume is minimal. A smaller volume would then require a reduced role of containment by the orbicularis oris. Erteiken *et al.*[8] and Vaiman [3] compared the intensity of activation between different volumes and between bolus and saliva, considering only the submental muscles: while both studies report that intensity increases together with the increase of bolus volume, regarding the comparison with saliva the results are in contrast as Erteiken *et al.*[8] recorded a higher intensity with saliva whereas Vaiman [3] with water. Our work found no difference of intensity in submental muscles and masseter comparing low viscosity consistencies (water and semi-liquid) with saliva. Probably with saliva, while there is no need of frontal containment, there is still a consistent activation of submental and masseter muscles for eliciting the swallowing reflex.

The present study reported some limits regarding both methods and data results. Starting and ending points of muscle activity could have been identified with more objective methods such as exceeding a certain threshold or basal EMG activity: with the raw data at our disposal and the nature of EMG curve, it was not possible to find a proper procedure in this sense. The same concern is for the EMG activity, where peak activity was omitted.

As mentioned above results reported showed a great inter subject and intra subject variability, and in consideration of the limited sample size, this could be another important limit of the study.

Conclusions

In conclusion, the present study contributed in describing the activity of three key muscles groups in the deglutition process, specifying how this changes in relation to bolus characteristics. sEMG technique was confirmed as a valid procedure to investigate this gesture: in particular the study reported as feasible the measure of sEMG intensity as percentage of maximal activation, bypassing the risk of biases due to electrodes positioning. Some of this information could contribute in selecting appropriate bolus consistencies for persons with deglutition disorders related to one or more dysfunction of the considered muscles, but prior to this, further studies on patients are advisable.

References

1. Crary MA, Carnaby GD, Groher ME: Identification of swallowing events from sEMG signals obtained from healthy adults. Dysphagia 2007;22:94-9.
2. Vaiman M, Eviatar E, Segal S. Surface electromyographic studies of swallowing in normal subjects: a review of 440 adults. Report 1. Quantitative data: timing measures. Otolariyng Head Neck Surg 2004;131:548-55.
3. Vaiman M, Eviatar E, Segal S. Surface electromyographic studies of swallowing in normal subjects: a review of 440 adults. Report 2. Quantitative data: amplitude measures. Otolariyng Head Neck Surg 2004;131:773-80.
4. Vaiman M, Eviatar E, Segal S. Surface electromyographic studies of swallowing in normal subjects: a review of 440 adults. Report 3. Qualitative data. Otolariyng Head Neck Surg 2004;131:977-85.
5. Perlman AL, Palmer PM, McCulloch TM, Vandaele DJ. Electromyographic activity from human laryngeal, pharyngeal and submental muscles during swallowing. J Appl Physiol 1999;86:1663-9.
6. Palmer PM, Luschei ES, Jaffe D, McCulloch TM. Contributions of individual muscles to the submental surface electromyography during swallowing. J Speech Lang Hearing Res 1999;42:1378-91.
7. Huckabee ML, Butler SG, Barclay M, Jit S. Submental surface electromyographic measurement and pharyngeal pressures during normal and effortful swallowing. Arch Phys Med Rehabil 2005;86:2144-9.
8. Ertekin C, Aydogdu I, Yuceyar N, Pehlivan M, Ertas M, Uludag B *et al.* Effects of bolus volume on oropharyngeal swallowing: an electrophysiological study in man. Am J Gastroenterology 1997;92:2049-53.
9. Leow LP, Huckabee ML, Sharma S, Tooley TP. The influence of taste on swallowing apnea, oral preparation time, and duration and amplitude of submental muscle contraction. Chem Senses 2007;32:119-28.
10. Reimers-Neils L, Logemann J, Larson C. Viscosity effects on EMG activity in normal swallow. Dysphagia 1994;9:101-6.

11. Crary MA, Baldwin BO. Surface electromyographic characteristics of swallowing in dysphagia secondary to brainstem stroke. Dysphagia 1997;12:180-7.
12. Vaiman M, Krakovski D, Gavriel H. Swallowing before and after tonsillectomy as evaluated by surface electromyography. Otolaryngology-Head and Neck Surgery 2007;137:138-45.
13. Ertekin C, Keskin A, Kiylioglu N, Kirazli Y, Yagiz A, Tarlaci S *et al*. The effect of head and neck positions on oropharyngeal swallowing: a clinical and electrophysiologic study. Arch Phys Med Rehabil 2001;82:1255-60.
14. Taniguchi H, Tsukada T, Ootaki S, Yamada Y, Inoue M. Correspondence between food consistency and suprahyoid muscle activity, tongue pressure, and bolus transit times during the oropharyngeal phase of swallowing. J Appl Physiol 2008;105:791-9.
15. Crary MA, Carnaby GD, Groher ME. Biomechanical correlates of surface electromyography signals obtained during swallowing by healthy adults. J Speech Lang Hearing Res 2006;49:186-93.
16. Inagaki D, MiyaokaY, Ashida I, Yamada Y. Influence of food properties and body posture on durations of swallowing-related muscle activities. J Oral Rehabil 2008;35:656-63.
17. Miyaoka Y, Haishima K, Takagi M, Haishima H, Asari J, Yamada Y. Influence of thermal and gustatory characteristics on sensory and motor aspect of swallowing. Dysphagia 2006;21:38-48.
18. Inagaki D, Miyaoka Y, Ashida I, Ueda K, Yamada Y. Influences of body posture on duration of oral swallowing in normal young adults. J Oral Rehabil 2007;34:414-21.
19. Maeda K, Ono T, Otsuka R, Ishiwata Y, Kuroda T, Ohyama K. Modulation of voluntary swallowing by visual inputs in humans. Dysphagia 2004;19:1-6.
20. Sciortino KF, Liss JM, Case JL, Gerrutsen KGM, Katz RC. Effects of mechanical, cold, gustatory, and combined stimulation to the human anterior facial pillars. Dysphagia 2003;18:16-26.
21. Dantas RO, Dodds WJ. Effect of bolus volume and consistency on swallow-induced submental and infrahyoid electromyographic activity. Braz J Med Biol Res 1990;23:37-44.
22. Monaco A, Cattaneo R, Spadaro A, Giannoni M. Surface electromyography pattern of human swallowing. BMC Oral Health 2008;8:6-16.
23. Ertekin C, Aydogdu I. Neurophysiology of swallowing. Clinical Neurophysiology 2003;114:2226-44.
24. Ding R, Larson CR, Logemann JA, Rademaker AW. Surface electromyographic and electroglottographic studies in normal subjects under two swallow conditions: normal and during the Mendelsohn manuever. Dysphagia 2002;17:1-12.
25. Knutson LM, Soderberg LG, Ballantyne BT, Clarke WR. A study of various normalization procedures for within day electromyographic data. J Electromyogr Kinesiol 1994;4:47-59.
26. Soderberg GL, Knutson LM. A guide for use and interpretation of kinesiologic electromyographic data. Phys Ther 2000;80:485-98.
27. Erb W. Handbuch der Electrotherapie. 2 Aufl Vogel, Leipzig, 1886.
28. Goodgold J. Anatomical correlates of clinical electromyography. Baltimore, MD: William & Wilkins; 1975.
29. Wheeler KM, Toni C, Sapienza CM. Surface electromyographic activity during submental muscles swallow and expiratory pressure threshold training tasks. Dysphagia 2007;22:108-16.

Received on January 31, 2011 - Accepted for publication on June 29, 2012.

Corresponding author: G. Corti, San Raffaele Hospital, via Olgettina 60, 20132 Milan, Italy. E-mail: corti.gustavo@hsr.it