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Influence of Target Size on Jump Convergence Assessment

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ABSTRACT

Convergence ability is a vital part of clinical binocular vision assessment. Convergence is the disjugate movement of both eyes nasal-ward and it may be expressed as pursuit convergence or as jump convergence. Jump convergence describes the quality of convergence demonstrated when binocular fixation on a target is swiftly alternated from a distant or mid-distant target to a near target, creating a saccadic motion. Jump convergence ability is utilised in daily visual tasks; it is a crucial component in clinical binocular vision assessment, diagnosis of convergence problems and vision therapy activities. This study was aimed at determining the effect of target size on jump convergence. The study was carried out on a sample size of 170 university undergraduates, aged 16 – 30 years of age in Imo state, Nigeria. Various target sizes (N8, N6 and N5) were used to assess jump convergence ability in the participants, in order to determine any influence by the different target sizes on the jump convergence outcomes. The study outcomes revealed a strong positive correlation between the different test target sizes indicating a positive relationship between jump convergence and the test target sizes. No statistically significant effect was established for age in this study for jump convergence at the different target sizes of N8, N6 and N5 ($P > 5\%$). The study concludes that target size must be considered during jump convergence assessments or activities and thus recommends the careful record of the test target size used for both jump convergence assessment and binocular vision training activities.

***Keywords*:** convergence, jump convergence, target size, binocular vision, saccadic, vision therapy

INTRODUCTION

Binocular vision is a state of simultaneous vision that is achieved by the coordinated efforts of the two eyes to focus at an object of regard, clearly.[1, 2] During the binocular viewing of a near target, the separate and slightly different images seen by each eye are fused into a single clear image, when an individual fixes his focus on the object of regard.[1] To achieve single clear binocular vision of a near target, the eyes converge, accommodation is stimulated and the pupils constrict - exhibiting the near triad of responses.[3] Convergence ability is a vital

component of binocular vision. Convergence refers to the disjugate movement of the eyes, in which both eyes simultaneously move nasal-ward, causing the two lines of sight to intersect in the front of the subject.[4] Convergence ability can be expressed as pursuit convergence or as saccadic/jump convergence, both of which can be assessed clinically. [5, 6, 7]

Jump convergence, describes the quality of convergence demonstrated when the fixation on a target alternately jumps swiftly from a distant or mid-distant target to a near target in a saccadic motion.[3] Also known as a saccadic vergent eye movement or as step vergence, jump convergence ability is said to be more likely utilised in real life scenarios.[5, 6, 8] The assessment of jump convergence ability is a vital aspect to consider in the diagnosis or determination of the presence of convergence problems.[7]

In clinical application, jump convergence activities can be applied as an assessment test to assess convergence ability or as therapeutic exercise routines during binocular vision therapy sessions for cases of convergence insufficiency and other binocular vision problems. Convergence ability and assessment is a vital component for binocular vision therapy activities;[9] it can done using the phasic/jump vergence training method, during which the vergence demand is quickly changed in large steps to apply jump convergence as well as using the pursuit vergence training exercises whereby the vergence demand is increased in a gradual manner to utilise pursuit convergence.[9] The efficacy of the jump exercises/phasic vergence training exercises have been established as very effective in the therapy procedures in fusional vergence dysfunctions, producing the significant improvement outcomes in vergence abilities.[9]

The procedure for jump convergence assessment is relatively easy to perform and it can be applied as an additional assessment in patients that show signs of convergence insufficiency or in those who have normal near point of convergence values but have symptoms of possible convergence difficulties.[3] However, findings from jump convergence assessments are not usually taken into consideration in the diagnosis of convergence insufficiency unlike pursuit convergence, probably due to its qualitative rather than quantitative nature.[3]

Purpose of study

This study observed the outcomes of the jump convergence assessments using three different target sizes in young adults, in order to determine the influence of target sizes on jump convergence ability. Jump convergence assessments are very crucial in binocular vision assessments and vision therapy procedures; unfortunately, poor standardisation of test targets used in jump convergence may influence routine and follow up outcomes of convergence assessment procedures.

Aim and objectives of the study

The aim of the study was to determine the influence of target size on jump convergence among young adults. The Objectives included:

i. To assess the jump convergence of normal binocularity subjects within the 16-30-year age group using single letter near test targets of varying sizes
ii. To compare the jump convergence results done with the various test target sizes.
iii. To determine the effect of different letter target sizes on jump convergence results among subjects with normal binocularity with respect to age groups

Significance of study

It has been recommended that caution should be exercised when comparing convergence outcomes from different studies because convergence outcomes may be influenced by factors such as the measurement methods, test targets, and population characteristics such as age.[10] Some authors recommend that one type of testing method for the diagnosis and follow-up monitoring of convergence insufficiency

should be adhered to.[11] These studies highlight the relevance of better standardization of test procedures and details such as target size, in convergence assessment methods.

Unfortunately, not much research evaluation has been done on jump convergence ability compared to pursuit convergence.[3] The outcome of this study exposes the effects of various letter target sizes on jump convergence values in the study population, contributing to the existing knowledge regarding the details of various test targets used in jump convergence assessments. It also reveals the extent of influence of test target size on jump convergence test outcomes. Such information is beneficial to guide clinicians on target choice and target size to be used for jump convergence testing, depending on the reason for the assessment. Furthermore, this study contributes to existing information toward the standardization of jump convergence testing targets, confirming the need for clinicians to record the test target details and target sizes used for baseline jump convergence assessment procedures. This can be useful in the comparative monitoring of jump convergence in the determination of the patient progress in binocular vision therapy activities.

MATERIAL AND METHODS

This study was carried out within the university community in Imo State University, Owerri, Imo State, Nigeria, using a comparative quantitative study design whereby three different test targets were used to assess jump convergence on young adults aged 16-30 years.[12] A sample size of 170 was derived based on the Yamane formula[13] with a 95% confidence interval, and applying purposive sampling by randomly drawing from eligible study participants.

The jump convergence test was administered to all the eligible participants for the study. This was done using single Snellen letters of the near chart of the sizes, N5 (20/30), N6 (20/40) and N8 (20/60), as the near letter target in free space[14] in order to assess the effect of different letter target sizes on jump convergence results. All results were duly recorded, collated, categorised and analysed accordingly. In order to improve sensitivity and minimise errors, each test was repeated thrice for each target size and the mean values noted.

For this study, ethical approval was obtained from the research and ethics committee of the Imo state university, Owerri. All the interested participants were properly briefed with details of the jump convergence test procedure to be performed on them. The candidates who gave written informed consent to be tested for this study were assessed. Proper care was taken throughout the research processes to maintain participants' anonymity and confidentiality.

All the participants who indicated interest in the study were pre-screened for systemic histories, ocular case histories, preliminary eye exams and ocular motility assessments. The exclusion criteria applied excluded those with binocular vision dysfunctions, corrected visual acuity worse than 20/40 in either eye, incidence of ocular trauma, pathologies affecting the binocular vision system, use of ocular or systemic drugs that may affect accommodation and binocular vision.[10]

Qualified participants underwent the jump convergence test thrice for each of the three test target sizes – N5, N6 and N8. Seated before the examiner at 60cm away from a distant visual acuity chart, each participant was properly positioned with head upright and eyes in a slightly downward gaze. With the exam room adequately illuminated, each subject was tested with their refractive correction (if any) in place, and the distant target was positioned so as not to be obstructed by the examiner. Each subject was then instructed to fixate on a given single letter of a size that is one line larger than his best distant visual acuity in his poorer eye on the distant visual acuity chart at 60cm. With the Royal air force rule (RAF) rule in place at the midline, the test

target of N5 size was then positioned before the subject at 20cm from the subject. The subject was then instructed to alternately fixate clearly and smartly with both eyes at the near target and then at the far target (60cm) and back again at the near target. This fixation change was continued by the subject for the duration of 1 minute when the examiner instructed them to stop.

During the process, the examiner observed and recorded the both eyes as they repeatedly converged, diverged and converged again (one cycle) for one minute in response to the alternating fixation at near and far, in order to determine the speed and accuracy applied in switching focus between both distances. The number of cycles completed in a minute (cycles per minute, cpm) was observed and recorded against the two target distances used, as well as the smoothness of the eye movement during the process.[8] This process for jump convergence (JC) was done with correction in place for each subject and repeated using the other near target sizes, N6 and N8.

The various data generated were collated in relation to the study objectives, to facilitate analysis. All data generated were categorised in relation to age classes within the age limit of the study (16 – 30 years), and the three target sizes used in the study; data distribution and description were done using statistical measures such as frequencies, percentages mean and standard deviations.

Statistical Analysis

Statistical analysis using tools such as t-tests were applied to compare the means of the three different tests targets; analysis of variance and general linear models were applied for the comparisons of the outcomes from the various test target sizes assessed among the age groups in order to test the proposed study hypotheses. All the analysis were done at 5% level of significance with probability value ($p < 0.05$) and 95% confidence interval (95% conf. Int.) applied for interpretation.

RESULTS

The sample size of 170 was used for this study, with the recorded average age of 22.2 years $\pm$3.26) from the age range of 16 – 30 years. A total of 70 (41.2%) were male and the remaining 100 (58.8%) were female participants.

The minimum and maximum jump convergence values for the three different target sizes are outlined in Table 1. The mean measurements on jump convergence did not vary so much between the three target sizes. The average values of jump convergence (JC) measurements for size N8 were 39.37cpm (std. dev = 7.621), 39.58 cpm (std. dev = 8.241) for size N6 and 40.02cpm (std. dev = 8.797) for size N5.

Table 1: Descriptive Statistics for jump convergence

JC Value	N	Minimum	Maximum	Mean	Std. Dev
Size N8	155	26.0	60.0	39.37	7.621
Size N6	155	25.0	60.0	39.58	8.241
Size N5	155	24.0	58.0	40.02	8.797

Table 2 displays the relationship between age and the jump convergence ability using different target sizes, N8, N6 and N5. Change in target size was shown to affect jump convergence, across all the age classes within the study sample. None of the target sizes (N8, N6 and N5) was found to differ significantly for the age classes (P >5%). For target sizes N8 and N6, the largest mean jump convergence value occurred on age group 20-22 years at 41.36 cpm (standard deviation=7.64) and 42.93 cpm (standard deviation=8.89) respectively, while it was highest at the less than 19 years old for target size N5 (Mean ± standard deviation: 41.71 ±10.1). The mean jump convergence for other age classes did not vary much comparatively. No statistically significant effect was established for age in this study

for jump convergence at the different target sizes of N8, N6 and N5 (P > 5%).

Table 2: Influence of target size on jump convergence assessment in the age groups

Age Class	N	JC (cpm) Size n8	JC (cpm) Size n6	JC (cpm) Size n5
		Mean ± st.d	mean± st.d	mean± st.d
< = 19	40	39.90±7.87	39.61±8.22	41.71 ±10.1
20 – 22	29	41.36 ±7.64	42.93 ±8.89	40.86 ±8.88
23 – 25	43	39.31±7.93	39.69 ±8.70	39.87 ±8.35
25 – 28	40	37.75±7.19	37.11 ±6.99	37.99±8.11
28+	4	36.25±7.50	38.50±2.08	38.75±0.96
Stat. Test		P=0.327, F =1.17	P=0.074, F =2.18	P=0.413, F =0.99

The data analysis of the jump convergence measurements showed strong positive correlation between the different target sizes. The correlations between size N8 and size N6 were 0.829, between size N8 and size N5 as 0.825 and between size N6 and size N5 was 0.858, with the strongest the correlation between sizes N6 and N5. The correlation coefficients are of indication that positive relationships exist in the JC for the changes in the target sizes.

DISCUSSION

Preliminary literature reviews on the jump convergence ability and normative values confirm the poor availability of information regarding normative values for jump convergence ability.[3] The study by Schieman *et al.*[15] recorded a mean jump convergence of 30 cpm with standard deviation of 10 for subjects with normal binocular vision and a mean jump convergence of 23 cpm with standard deviation of 11 for subjects with convergence insufficiency. From the results of this study, the average values of jump convergence measurements in corrected ametropes were recorded as 39.37cpm (st. dev = 7.621) on size n8, 39.58 cpm (st. dev = 8.241) for size n6 and 40.02cpm (st. dev = 8.797) for size n5. Although these mean values are generally higher than that reported by Schieman *et al.*[15] for subjects with normal binocular vision, the sample size used by Schieman *et al.*[15] was only 10.

Some external factors have been shown to influence convergence outcomes. This study outcomes show that target size does influence jump convergence outcomes. A study by McGinnis *et al.* [16]evaluated the effect of some target qualities and factors (namely the target speed and the verbal instructions) on the near point of convergence by measuring NPC in 20 individuals utilising three target speeds and two sets of verbal instruction.[16] The results showed a significant difference in NPC results between the various target speeds as well as a difference between the responses to the two sets of verbal instructions. The study concluded that for the population of young, healthy and active individuals, external factors such as target speed and verbal instruction can affect the outcomes when measuring NPC.[16] Although the McGinnis *et al.*[16] study did not assess test target size as this study did, their results show that factors relating to convergence test targets such as speed, can affect the test results.

Test target types used in convergence assessments have been demonstrated to influence other convergence outcomes. Some studies have established a relationship between target types and size and pursuit convergence in certain conditions.[9, 17] Siderov *et al.*[17] measured the NPC in 20–85 years old subjects using different types of targets; their study showed that the NPC results were indeed influenced by the type of target used for the test, however this was only recorded among the younger populations but not in the presbyopic age range. Outcomes of the study by Heick and Bay[9] which required healthy recreational athletes to participate in a comparison study of 4 commonly used targets in the measurement of NPC: a 12-point font target,

a 14-point font target, the tip of a black pen, and a 9-point font target in a randomised order, revealed that target size affected pursuit convergence results. Based on their study outcomes, they recommended that the target used to measure NPC as a screening test for concussion should be standardized since the results show differences depending on the target used in the assessment of NPC.[9] This is in agreement with the outcomes of this study, although the targets employed in their study were not uniform in nature as they utilised a combination of font sizes and solid objects (the tip of a pen) to assess the effect of target size on NPC results. In this study, the results reveal that in comparison, jump convergence outcomes were influenced by the changes in the target sizes.

CONCLUSION

Convergence ability and assessment is critical in eye care and the attainment of single comfortable binocular vision. This study results lead to the conclusion that target sizes for convergence assessment and binocular vision training exercises (involving jump convergence), should be standardised as they can affect the final outcomes of the jump convergence results. The varying effects on the outcomes of jump convergence due to change in test target size indicate that the factor of target size must be considered during convergence assessment.

The conclusion drawn from this study imply firstly that that during training or assessment involving jump convergence, the target size used for the initial assessment should be noted and recorded in order to inform the choice of target size in the follow up assessments. Furthermore, in cases where there is need or comparison on results, such comparison should be based on jump convergence results that used the same target size.

Declaration by Authors

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