Chapter 5
Discussion

Discussion

In this chapter, an endeavour has been made to discuss the results obtained from the data analyses given in Chapter-4. The prominent statistical tools being ANCOVA with post hoc (t) comparisons of adjusted means, graphical trends with least square solutions (together with linear equations), and other graphical presentations. The demographic results obtained through McGill Pain Questionnaire have been discussed at the suitable place. The results have been discussed in the light of hypotheses formulated for the study, theoretical models available on the subject, and the studies already conducted in this regard.

5.1. PAIN

The present study relates to the problem of cervical spine pain in the subjects and investigates the research question: ***Is NAGs more effective treatment for neck pain in comparison to available conventional methods of treatment?***

Figure 4.112 shows the recovery patterns of VAS scores of present status (the overall general pain in cervical spine perceived by the subject at that particular given point of time), of all the Groups, from day 1 to day 42. The subjects in experimental Group 1 (blue) receiving NAGs on all 12 days along with conventional physiotherapy showed better recovery than experimental Group 2 (red) receiving NAGs only for the first 6 days along with conventional physiotherapy and receiving only conventional physiotherapy from day 7 onwards. Similarly the subjects in experimental Groups 1, and 2, showed better recovery than those in Group 3 (green) receiving only conventional physiotherapy on the initial 6 days and NAGs along with conventional physiotherapy in last the 6 days, i.e., from day 7 to day 12. It is pertinent to note that the subjects in control Group, i.e., Group 4 (purple) receiving only conventional physiotherapy throughout the observation period, i.e., from day 1 to day 12, showed least recovery in terms of pain in comparison to experimental Groups 1, 2, and 3, as it is evident from Table 4.12, showing the post hoc comparisons (t) among the adjusted means of VAS scores (present status) between O_1 (pre-treatment) and O_{14} (average of

6 post-treatment observations, i.e. O_2, O_4, O_6, O_8, O_{12} and O_{13}) of all the four Groups. Table 4.12 and Figure 4.22 exhibit that highly significant differences were found among the subjects in Groups 1 vs 3, 1 vs 4, 2 vs 3, and 2 vs 4. Attributing the recovery to the positional fault theory (Exelby, 2002), mechanical neck pain is usually associated with zygapophyseal joint mal-tracking. Mulligan (1999) stated that physiology of NAGs could be explained as appropriate accessory movement correcting the mechanical block within a joint and making the joint return to its physiological position. These techniques are unique because they consist of the application of accessory glide to a joint after which the patient performs a previously painful movement of that joint (Mulligan, 1999). It may also be concluded that better overall reduction in pain in other postures results in better overall VAS (present status).

It has been observed that on day 12, the subjects in experimental Group 3 who received NAGs for the last 6 days showed better recovery than those in control Group (Group 4) who were not given NAGs at all. Table 4.8 and Figure 4.20 highlight these results quite clearly. Further, significant difference among the subjects in Groups 1 vs 3 can also be observed from the table. The subjects in Group 3 received NAGs only for the last 6 days, while those in Group 1 received it throughout the observation period. Highly significant differences have been observed among the subjects in Groups 1 vs 4, and 2 vs 4 (Table 4.8, Figure 4.20). It is pertinent to note that till day 6; no significant difference was seen among the subjects in Groups 3 vs 4 (Tables 4.2, 4.4, and 4.6). The subjects in experimental Group 3 were also not receiving NAGs like those in control Group (Group 4), and when the NAGs were administered to the subjects in Group 3 from day 7 onwards, significant differences were observed. It is evident from Figure 4.112 that VAS scores registered a steep fall after the NAGs were administered to the subjects in Group 3 from day 7 onwards. Sympatho-excitatory effect of mulligan technique can be taken into account to advocate the decrease in pain after giving NAGs (Moulson and Watson, 2006).

It is pertinent to note that the description given in Chapter-4 with respect to Figure 4.112 takes into account the linear functions derived from the total outcome of 12 days and follow-up. However, it is observed from the data that 1st seven days were very crucial for the treatment, that is, the rate of change (drop) in the dependent measure was very quick during the 1st seven days, and after that the curve started forming plateau as much of the recovery had already taken place. Therefore, interpreting the outcome for the 1st seven days will be very crucial. If we observe the experimental Group 1 (blue) the fall in the curvature is very steep from 1st to the 7th day. For experimental Group 2 (red) it is similar with respect to the slope function. Experimental Group 3 (green) had slower recovery till day 6 and steep fall was seen as the NAGs administered to the subjects were started from day 7 onwards. Lastly, in the control Group 4 (purple) the fall has consistently been slow. This indicates that NAGs are more effective treatment in comparison to conventional methods of treatment.

On the basis of above discussion, it can be said that the subjects in Group 1 (receiving NAGs throughout 12 days of observation), showed better recovery than those in Group 2 (receiving NAGs only for the initial six days), followed by the subjects in Group 3 (receiving NAGs only for the last 6 days), and those in Group 4 (receiving only conventional physiotherapy throughout the period of observation) in that order. This supports the research hypothesis **H1: Experimental Groups receiving NAGs will show better outcomes in comparison to the control Group.**

Another problem related to cervical spine pain for which this study has been addressed is: ***Do NAGs reduce pain immediately as compared to the available conventional physiotherapy treatment?***

It is observed from Figure 4.112 that the subjects in experimental Groups 1 (blue) and 2 (red) receiving NAGs from the very 1st day had lesser pain after the treatment on day 1 itself as compared to those in experimental Group 3 (green) and control Group (Group 4, purple). A steep fall in VAS scores was seen in Groups 1, and 2 (Figure 4.112). Table 4.2 and Figure 4.17 also support this finding, where highly significant differences have been observed among the subjects in Groups 1 vs 3, 1 vs 4, 2 vs 3, and 2 vs 4. Similarly, highly significant differences have been observed again on day 6 and 7 (Tables 4.4, and 4.6; Figures 4.18, and 4.19). NAGs helps in reducing pain immediately is also supported by the results presented in Figure 4.112 showing steep fall in VAS scores in Group 3 on day 7, as the NAGs are introduced, though statistically non-significant difference is observed among the subjects in Groups 3 vs 4. While on day 12 significant difference is observed among the subjects in Groups 3 vs 4 (Table 4.8 and Figure 4.20).

It may be derived from the above discussion that NAGs helps in immediate reduction of pain, but requires continuous treatment for few more days to have a lasting effect. This supports the research hypothesis **H2: Groups receiving NAGs will show immediate recovery in terms of pain and range of motions.**

Another problem relating to cervical spine pain addressed by this study is: ***Do NAGs have a long-term effect in pain management?***

Observation 13 taken on day 42 as follow-up assessment shows (Figure 4.112) that the subjects in experimental Groups 1 and 2 showed recurrence of a very minimal amount of pain (as reflected by VAS scores) as compared to day 12. However, in experimental Group 3 and control Group (Group 4) there was further reduction in VAS scores (though very minimal) on day 42 as compared to day 12. This is probably due to full recovery of the subjects in Group 1 and 2 by day 12 and reached almost VAS scores (mean) of 0 and 0.2 respectively, while those in Groups 3 and 4 were still having scope for further recovery with VAS scores (mean) 0.4 and 0.72 respectively. On day 42, a significant difference was seen among the subjects in Groups 3 vs 4, while those in Group 1 vs 4 and 2 vs 4 did not show significant difference at the conventional level of confidence $p<.05$, but, it was found to be significant at $p<0.1$ level of confidence (Table 4.10 and Figure 4.21). It is pertinent to note from Figure 4.21 that the subjects in Groups 1, 2 and 3 had lower mean (adjusted mean) of VAS scores as compared to those in control Group (Group 4).

The above discussion leads us to say that NAGs not only has an immediate effect on pain management but also have a long lasting effect on it. It is also observed that in order to have a lasting effect of NAGs, it is important to give NAGs for a number of days and single treatment of NAGs will not be good enough to have a long lasting effect. This supports the research hypothesis **H3: Groups receiving NAGs will show long lasting effects on pain relief and increased range of motions.**

VAS (Neutral Neck Position)

To see the effect of the NAGs on pain, VAS scores are also measured with the neck in neutral position and in available end range of motion. VAS measured in available end range of motion and its relation with range of motion will be discussed later in this chapter. The general trend of VAS scores (neutral neck position) also shows almost similar recovery pattern as VAS scores present status. However, there are few outcomes, which are either non-significant or significant at the level of $p<.1$. This is supported by the linear curve shown in Figure 4.113, where all the three experimental Groups (Group 1, 2, & 3), show improvement over the control Group (Group 4). The same is also depicted by the linear curve shown in Figure 4.113, which measures its steepness. Our observations are also supported by post hoc comparisons (t) among the adjusted means of VAS scores (neutral neck position) between O_1 (pre-treatment) and O_{14} (average of six post treatment observations O_2, O_4, O_6, O_8, O_{12}, and O_{13}) of all the four Groups (Table 4.24 and Figure 4.28). This result also supports the hypotheses H1, H2, and H3 as discussed earlier in this chapter.

Moulson and Watson (2006) brought out that sympatho-excitatory effect of mulligan technique can be taken into account to advocate the decrease in pain after giving NAGs. The activation of afferent nerve endings through manual contact influences the spinal cord neurons, inhibiting nocioception and motor neuron pool (Hearn and Rivett, 2002); this also can be a reason that marks the reduction of pain in neutral position. Mechanoreceptors involved in the pain modulation get stimulated as a consequence of stretch of the capsule brought about by spinal mobilization. An afferent impulse is sent to higher centers through the large diameter myelinated neurons, which modulates and inhibits the incoming nociceptive information. Passive joint mobilisation may, therefore, provide pain relief by activating this spinal gate control mechanism (Melzack and Wall, 1965). NAGs provide physiological movement within the joint, with this movement circulation and nutrition to the joint improves. An increased circulation wash out the nociceptive stimuli and better nutrition heals minor injuries sustained by soft tissue entrapped within.

Pain is also an emotional disturbance, which has some psychological influence too. Spinal mobilization exerts a psychological influence on the pain perception of the patient. Though the hands were placed for the placebo effect only, but, it may have strong psychological effect for a patient. This may occur directly or indirectly via the neuromuscular system, through muscle tension reduction (Gross *et al.,* 1996). Natural alignment and removal of irritating stimuli, in turn diminish the pain. Along with neck pain, other disabling features of neck disorders are decrease in range of motion (Armstrong *et al.,* 2005 & Dall'Alba *et al.,* 2001), and altered position sense (Rix and Bagust, 2001). Excitation of proprioceptors by NAGs also helps in better joint positioning.

5.2. RANGE OF MOTION

Another main problem related to the stiffness of cervical spine for which this study is addressed: ***Is NAGs more effective treatment for stiffness (flexion) of cervical spine in comparison to available conventional methods of treatment?***

Flexion was most painful and hence limited, after being treated with NAGs, ranges were both better and pain free. As flexion was the main problem in majority of the subjects, 46 out of 100 complained stiffness while doing flexion range of motion (ROM) (Figure 4.11). First of all, the effects of NAGs on flexion as range of motion have been discussed.

Figure 4.120 shows the recovery patterns of range of motion (flexion), of all the Groups, from day 1 to day 42. The subjects in experimental Group 1 (blue) who were given NAGs on all 12 days along with conventional physiotherapy, showed better recovery than those in experimental Group 2 (red) who were provided NAGs only for the initial 6 days with conventional physiotherapy and those given only conventional physiotherapy from day 7 onwards. The subjects in experimental Groups 1 and 2 have shown better recovery than those in experimental Group 3 (green) receiving only conventional physiotherapy for the initial six days and NAGs along with conventional physiotherapy in the last 6 days, i.e., from day 7 to day 12. It is significant to note that the subjects in control group, i.e., Group 4 (purple) who received only conventional physiotherapy throughout the period of observation i.e., from day 1 to day 12, showed least recovery in terms of flexion (ROM) as compared to those in experimental Groups 1, 2, and 3; and it is quite evident from Table 4.106 showing the post hoc comparisons (t) among the adjusted means of ROM (flexion) between O_1 (pre-treatment) and O_{14} (average of 6 post-treatment observations, i.e., O_2, O_4, O_6, O_8, O_{12} and O_{13}) of all the four Groups. Table 4.106 and Figure 4.69 depict that highly significant difference were seen among the subjects in Groups 1 vs 4, and 2 vs 4, while significant differences in Groups 1 vs 3, and 2 vs 3 were observed. The results show that the subjects in Group 1 who were treated with NAGs gained significantly better ranges as compared to those in control Group 4.

Better plane of movement and physiological gliding attained by NAGs throughout the range helps in increasing the ranges. As in flexion, biomechanically, vertebrae tilt and translate anteriorly; it is achieved when glide do the translation and movement followed completes the tilting component. Movement in anatomical way makes it easier and pain free. McConnell (1996) has biomechanically explained that due to trauma or muscle recruitment imbalance, the patella may develop a “tracking mechanism problem”. It is suggested that such a phenomenon may equally occur with the spinal apophyseal joints. Dramatic increase in range and decrease in pain can be explained using the analogy of a “drawer stuck in its runners”. The drawer is not “out of place” but rather it is “not tracking properly”. During NAGs the superimposition of an accessory movement onto the patient’s active physiological movement over-rides the obstruction and re-establishes correct alignment. The accessory movement takes the joint through what would be the normal physiological movement of the joint. The pre-injury joint tracking is re-established reasserting the ‘joint memory’ or prior conditioning of the healthy joint. Exelby (2001) suggested that a number of investigative procedures like EMG, ultrasound, etc. should be used in the comparative studies to test whether there are any advantages to the use of MWMs on segmental muscle activity, kinesthetic sense and pain when compared with other passive manual therapy techniques.

Table 4.96 and Figure 4.64 present the post hoc comparisons (t) among the adjusted means of cervical spine ROM (flexion) between O_1 and O_2 of different Groups on day 1. Highly significant differences among the subjects in Groups 1 vs 3 , and 2 vs 3, and clinically significant differences (not significant at the conventional level of $p<.05$), at the level of $p<0.1$ were observed among the subjects in Groups 1 vs 4, 2 vs 4, and 3 vs 4. On day 2 (post-treatment), all the comparisons remained the same except among the subjects in Group 2 vs 4 that increased from $p<.1$ to significant level $p<.05$ (Table 4.98 and Figure 4.65). These significant differences kept on increasing among the subjects in all the Groups till day 6 as highly significant differences were observed (Table 4.100 and Figure 4.66) on day 6 (post-treatment) among those in Groups 1 vs 3, 1 vs 4, 2 vs 3, and 2 vs 4. While on day 7 (post-treatment), these comparisons were reduced from highly significant differences to significant differences (Table 4.102 and Figure 4.67), and there was no significant difference seen on the last day (day 12) among the subjects in any of the Group. Now, if we see these post hoc comparisons in the light of linear function (Figure 4.120), it is observed that the subjects in Groups 1 and 2 receiving NAGs gained flexion (ROM) much before and faster than those in Groups 3 and 4. Steady increase in ROM was also observed in subjects under Group 3 after the administration of NAGs on day 7. Initially, an increasing trend in the significant difference was seen among the experimental and control groups, and then it started to decrease showing non-significant difference. This is because the subjects in Groups 1 and 2 receiving NAGs showed a quick increase in ROM during the initial seven days, and after that the curve started forming plateau as maximum recovery had already taken place, while those in Groups 3 and 4 were still improving (because of slower pace of recovery) and reached almost the same level of recovery on day 12. It is evident from Figure 4.120 that the subjects in Group 3 had recovered faster and showed more improvement in ROM from day 7 onwards as compared to those in control group (Group 4).

It is pertinent to note that the description given in chapter 4 with respect to Figure 4.120 takes into account the linear functions derived from the total outcome of 12 days and follow-up. However, it is observed from the data that first 7 days are very crucial for the treatment, that is, the rate of change in the dependent measure is very quick during the first seven days, and after that the curve started forming plateau as maximum recovery had already taken place. Therefore, interpreting the outcome for the first seven days will be very crucial. If we observe the experimental Group 1 (blue) the rise in the curvature is very steep from day 1 to day 7. Those in experimental Group 2 (red) have shown a similar position with respect to the slope function. As far as experimental Group 3 (green) is concerned, there was slower recovery till day 6 and great recovery was seen after the NAGs were administered on 7^{th} day onwards. Lastly, in the control Group 4 (purple) the rise has been constantly slow. This indicates that NAGs are more effective treatment in comparison to conventional methods of treatment.

The above discussion leads us to conclude that the subjects in Group 1 (who received NAGs for all the 12 days), showed increased ROM (flexion) than those in Group 2 (who received NAGs only for the first six days), followed by the subjects in Group 3 (who received NAGs only for the last 6 days), and those in Group 4 (who received only conventional physiotherapy throughout the observation period). This supports the hypothesis **H1: Experimental Groups receiving NAGs will show better results in comparison to the control Group.**

The study addresses the next sub-problem related to cervical spine stiffness as: ***Do NAGs reduce joint stiffness (flexion) immediately in comparison to available conventional methods of treatment?***

It is observed from Figure 4.120 that the subjects in experimental Groups 1 (blue) and 2 (red) who received NAGs from the very first day increased ROM (flexion) after the treatment on day 1 itself as compared to those in experimental Group 3 (green) and control Group (Group 4, purple). A steep rise in ROM was observed in both Group 1 and 2 (Figure 4.120). Table 4.96 and Figure 4.64 support it, where highly significant differences were seen among the subjects in Groups 1 vs 3, and 2 vs 3; and clinically significant differences (not significant at the conventional level of $p<.05$), at the level of $p<0.1$ were observed among the subjects in Groups 1 vs 4, 2 vs 4, and 3 vs 4. On day 2 (post-treatment) all the comparisons remained the same except between Group 2 vs 4 that increased from $p<.1$ to significant level $p<.05$ (Table 4.98 and Figure 4.65). Though no significant difference was seen among the subjects in Group 3 vs 4 on day 7, as NAGs were started for Group 3, but a steep rise in ROM was observed (Figure 4.120) from this day as compared to control Group (Group 4).

The above discussion provides that NAGs help to increase immediately the range of motion (flexion), but the subjects require continuing treatment for few more days to have a lasting effect. This supports the hypothesis H2: Groups receiving NAGs will show immediate recovery in terms of pain and range of motions.

The present study addresses the next sub-problem related to cervical spine stiffness as: ***Do NAGs have a long-term effect in maintaining range of motion (flexion)?***

Observation 13, taken on day 42 as follow-up assessment, shows (Figure 4.120) that in experimental Group 2 and control Group (Group 4), there was a quite minimal ROM (flexion) returned as compared to day 12. However, in experimental Groups 1 and 3 there was further increase in flexion ROM (though quite minimal) on day 42 as compared to day 12. This is probably due to full recovery of the subjects in Group 2 by day 12 and reached almost full ROM (mean) of 55, while those in Group 1 and 3 were still having scope for further recovery. On day 42, highly significant differences were observed between Groups 1 vs 4, and 3 vs 4. While Group 2 vs 4 had only a significant difference, and 2 vs 3 did not show any significant difference at the conventional $p<.05$ level of confidence. It was found to be significant at $p<0.1$ level of confidence (Table 4.104 and Figure 4.68). It is pertinent to note from Figure 4.68 that Groups 1, 2 and 3 had higher means (adjusted mean) of ROM (flexion) as compared to control Group (Group 4).

The above discussion provides that NAGs not only helps in increasing the ROM (flexion) immediately but also have a long lasting effect on it. It is also observed that in order to have its lasting effect, it is necessary to give NAGs for a number of days and single treatment of NAGs will not be sufficient for the purpose. It supports the hypothesis **H3: Groups receiving NAGs will show a long lasting effect on pain relief and increased range of motions**.

As many as 12 subjects out of 100 complained stiffness while doing extension range of motion (ROM) (Figure 4.11). So, the effects of NAGs on extension as range of motion have been studied in the following paragraphs.

Now the question is: Is NAGs more effective treatment for stiffness (extension) of cervical spine in comparison to other available conventional methods of treatment?

Figure 4.121 shows the recovery patterns of ROM in extension for the cervical spine, of all the Groups, from day 1 to day 42. The subjects in experimental Group 1 (blue) receiving NAGs on all 12 days along with conventional physiotherapy showed better recovery than those in experimental Group 2 (red) who received NAGs only for the initial 6 days along with conventional physiotherapy and those who received only conventional physiotherapy from day 7 onwards. The subjects in experimental Group 1 and 2 showed better recovery than those in experimental Group 3 (green) who were treated through only conventional physiotherapy on the first six days and NAGs along with conventional physiotherapy for the last 6 days, i.e., from day 7 to day 12. It is pertinent to note here that the subjects in control Group, i.e., Group 4 (purple) who were treated with only conventional physiotherapy throughout the observation period, i.e., from day 1 to day 12, showed least recovery in terms of ROM (extension) when compared with experimental Groups 1, 2, and 3; and it is also quite evident from Table 4.120 showing the post hoc comparisons (t) among the adjusted means of ROM (extension) between O_1 (pre-treatment) and O_{14} (average of 6 post-treatment observations, i.e., O_2, O_4, O_6, O_8, O_{12} and O_{13}) of all the four Groups. Table 4.120 and Figure 4.76 display highly significant difference between Groups 1 vs 3, 1 vs 4, 2 vs 3, 2 vs 4 and 3 vs 4. It was also observed that on day 12, the subjects in experimental Group 3 who received NAGs for the last 6 days showed better recovery than those in control Group (Group 4) who were not treated with the NAGs at all. The same is evident from Table 4.116 and Figure 4.74 that shows the significant difference between Group 3 vs 4. The table also shows highly significant differences observed between Groups 1 vs 4, and 2 vs 4. It is pertinent to note that till day 6, no significant difference was seen between Group 3 vs 4 (Table 4.112 and Figure 4.72) as experimental Group 3 was also not receiving NAGs like control Group (Group 4), but highly significant difference was observed after the subjects in Group 3 from day 7 onwards were treated with the NAGs (Table 4.114 and Figure 4.73). Figure 4.121 clearly highlights that there was a steep rise in the ROM (extension) after the NAGs were administered to the subjects in Group 3 from day 7 onwards.

The linear functions derived from the total outcome of 12 days and follow-up depict that the initial seven days were very crucial for the treatment, that, is the rate of change in the dependent measure was very quick during the initial seven days, and after that the curve was less steep as the maximum recovery already took place. Therefore, interpreting the outcome for the initial seven days was very crucial. If we observe the experimental Group 1 (blue) the rise in the curvature is very steep from day 1 to day 7. In the case of experimental Group 2 (red) a similar pattern was observed with respect to the slope function. The subjects in experimental Group 3 (green) had slower recovery till day 6, but they showed fast recovery after the NAGs were administered on 7th day onwards. Lastly, in control Group 4 (purple) the rise had been constantly slow. This indicates that NAGs were effective in treatment for cervical spine stiffness especially the extension as compared to the conventional methods of treatment. It supports the hypothesis **H1: Experimental Groups receiving NAGs will show better result in comparison to the control Group.**

Now, the question arises, will there be an immediate effect of NAGs to gain range of motion for extension also?

Therefore, the present study addresses the next sub-problem related to cervical spine stiffness as: ***Do NAGs reduce joint stiffness (extension) immediately in comparison to available conventional methods of treatment?***

It can be observed from Figure 4.121 that the subjects in experimental Groups 1 (blue) and 2 (red) who received NAGs from the very first day had increased ROM (extension) after the treatment on day 1 itself as compared to those in experimental Group 3 (green) and control Group (Group 4, purple). A steep rise in ROM (extension) was observed in both the Groups 1 and 2 (Figure 4.121). Table 4.108 and Figure 4.70 support this contention as highly significant differences were seen between Groups 1 vs 3, 1 vs 4, 2 vs 3, and 2 vs 4. However, this effect was lost on 2nd day (as a little stiffness again appeared in subjects belonging to all the four Groups), but similar highly significant differences were observed again on day 2 and day 6 (Tables 4.110 & 4.112 and Figure 4.71 & 4.72). The steep rise in ROM (extension) in Group 3 subjects on day 7 (observation 8) after the NAGs were started. Figure 4.121 supports our contention that NAGs help in reducing stiffness immediately. This is supported by the results given in Tables 4.108, 4.110 and 4.112 where no significant differences were seen between Group 3 vs 4 starting from day 1 to day 6 as the subjects in these groups were receiving the same treatment. From day 7 onwards NAGs were added to Group 3 and highly significant differences were observed between Group 3 vs 4 on day 7 itself (Table 4.114 and Figure 4.73). These highly significant differences continued till day 12 (Table 4.116 and Figure 4.74) between Groups 1 vs 4, 2 vs 4, and 3 vs 4.

The above discussion shows that though NAGs help in immediate increase in ROM (extension), but these require to be continued for few more days to have a lasting effect. This supports the hypothesis **H2: Groups receiving NAGs will show immediate recovery in terms of pain and range of motions.**

The study addresses the next sub-problem related to cervical spine stiffness as: ***Do NAGs have a long-term effect in maintaining range of motion (extension)?***

Observation 13 taken on day 42 as a follow-up assessment (Figure 4.121) shows that in experimental Groups 1, 2 and control group 4, a very minimal range of motion (extension) had returned as compared to day 12. However, in experimental Group 3 it was maintained on day 42 as compared to day 12. This is probably due to full recovery of the subjects in Groups 1 and 2 by day 12, and they attained almost full range of motion. Though, Group 4 subjects were still having scope for further recovery who had shown a slight decrease in range of motion probably due to lack of mobilization, i.e., NAGs. On day 42, highly significant differences were seen between Groups 1 vs 4, 2 vs 4, and 3 vs 4. It is interesting to note from the results exhibited in Figure 4.75 that Groups 1, 2 and 3 had higher mean (adjusted mean) of range of motion (extension) as compared to control Group (Group 4).

The above discussion shows that NAGs not only help in increasing the ROM (extension) immediately but also have a long lasting effect on it. It is also observed that in order to have a lasting effect of NAGs, it is important to give NAGs for a number of days and single treatment of NAGs will not be sufficient. This supports the hypothesis **H3: Groups receiving NAGs will show a long lasting effect on pain relief and increased range of motions.**

The study conducted on extension ROM also shows that pain and range were better in Group 1 when compared with others. Extension directly brings more load on the facet joints and the narrowing of spinal canal can further increase the pain. Biomechanically, the disc and the facets are the connecting structures between the vertebrae for the transmission of external forces. Their degeneration impairs the cervical spine function, mobility and causes pain (Shedid and Edward, 2007). Wilson (2001) summarized that the core of Mulligan's work in symptom free joint mobilization added to muscular activity. He explained that Mulligan techniques are used to correct minor joint derangements that often display a disproportionate array of effects. When uncus bears more direct load under vertebra above it grows postero-lateral osteophytes. These frequently invade the intervertebral canal in middle aged and elderly population (Bohlman and Emory, 1988). NAGs given overcome minor derangement of joints. Muscle activity is thought to occur in response to pain (Travell and Simmons, 1983) and increased muscle excitability in response to joint pathology or pain provocation has been demonstrated in animal models (Ferrell *et al.,* 1988; & Qing-Ping and Woolff, 1995). If increased muscle activity occurs in response to pain, then it would be expected that muscle activity might reduce if the level of pain reduces (Katavich, 1998). As it is a common belief that muscle activity contributes to stiffness detected by applied mobilizing forces, reducing pain and subsequently associated muscle activity, may lead to a decrease in stiffness. Lesser pain combined with better plane of movement and added muscular activity increase the range of motion in turn. It was seen while co-relating the results, the subjects in Group 1 and Group 2 showed improvement during the first 6 days of treatment and those in Group 3 also responded well when treated with NAGs from day 7 onwards. Those in control Group (Group 4) showed some improvement but it was far less as compared to the results obtained after the application of NAGs in other subjects.

Side Flexion

Side flexion jams the facet joint on the side at which movement is taking place. Compressive forces in already degenerated joint increases the pain. Lateral bending is a combination of upward movement on one side and downward movement on the other side. Thus, lateral bending to the left is coupled with rotation to the left and vice versa (Panjabi *et al.,* 1991b). Movement is restricted and painful because the lateral nerve roots are at greater risk of entrapment in the foramina by both facet and uncovertebral osteophytes. The effects of the NAGs are observed on range of motion for cervical spine in all ranges. The general trend of ROM (left side flexion) also shows almost similar recovery pattern as ROM for flexion and extension. This is supported by the linear curve shown in Figure 4.124, where all the three experimental Groups (Group 1, 2 & 3) show improvement over the control Group (Group 4). However, there are few outcomes, which are either non-significant or significant at the level of $p<.1$. This is supported by the linear curve function shown in Figure 4.124, where all the three experimental Groups (Group 1, 2 & 3) show improvement over the control Group (Group 4). It is quite evident from Table 4.58 and Figure 4.45 showing the post hoc comparisons (t) among the adjusted means of ROM (left side rotation) between O_1 (pre-treatment) and O_{14} (average of 6 post-treatment observations, i.e. O_2, O_4, O_6, O_8, O_{12} and O_{13}) of all the four Groups. This outcome also supports the hypotheses H1, H2 and H3 as discussed earlier in this chapter.

It is pertinent to note that the observations obtained for right side rotation are not consistent with other recovery pattern of ROM for cervical spine. Figure 4.125 shows that experimental Group 3 has the maximum recovery followed by Groups 4, 2, and 1. Group 4 with a steeper graph has shown better recovery than Groups 1 and 2 (Figure 4.125). However, this is not supported by any of the post hoc comparisons (t) among the adjusted means of ROM in right side flexion (Tables 4.135 to 4.144 and Figures 4.84 to 4.88). This marginal improvement in control Group (Group 4) as observed in Figure 4.125, should not be considered important, as differences are non-significant on post hoc comparisons as compared to experimental Groups 1 and 2. Further, the description given in chapter-4 with respect to Figure 4.125 takes into account the linear functions derived from the total outcome of 12 days and follow-up. However, it is observed from the data that initial 7 days were very crucial for the treatment, that is, the rate of change in the dependent measure was very quick during the first seven days, and after that the curve started forming plateau as maximum recovery had already taken place. Therefore, interpreting the outcome for the first seven days will be very crucial. If we observe the experimental Group 1, the rise in the curvature is very steep from day 1 to day 7. For experimental Group 2, it is similar with respect to the slope function. Experimental Group 3 has slower recovery till day 6 and steep rise seen as the NAGs administered on 7th day onwards. Lastly, in control Group 4, the rise has been constantly slow. This indicates that NAGs are more effective treatment in comparison to conventional methods of treatment. This outcome also supports the hypotheses H1, H2, and H3 discussed earlier in this chapter. During side flexion unilateral NAGs glides the facet and the space created avoids entrapment of nerve roots, hence, increasing the range that too in a pain free manner. Failure of the one column in joints to glide properly may result in an altered instantaneous axis of rotation and increased another column stress (Gertzbein, 1985; White and Panjabi, 1978, & White and Sahrmann, 1994). It may be this intimate relationship that can best explain why NAGs that would appear to principally affect apophyseal joint function are often dramatically effective (Bogduk and Twomey, 1991). This is further supported by adjusted means of ROM (right side flexion) of all the relevant post hoc comparisons (t) that Group 4 had minimal ROM (adjusted means) as compared to other experimental Groups. Difference between left side and right side rotation might have been due to right hand dominance, which is observed in majority of the population.

Rotation

The effects of the NAGs are observed on range of motion for cervical spine in all ranges. The general trend of ROM (left side rotation) also shows almost similar recovery pattern as ROM for flexion and extension. This is supported by the linear curve (Figure 4.124), where all the three experimental Groups (Group 1, 2 and 3) show improvement over the control Group (Group 4). Significant differences have been observed between experimental and control Groups. The same is also depicted by the curve shown in Figure 4.124, measured by the steepness of the curve. It is quite evident from Table 4.158 and Figure 4.95 showing the post hoc comparisons (t) among the adjusted means of ROM (left side rotation) between O_1 (pre-treatment) and O_{14} (average of 6 post-treatment observations, i.e. O_2, O_4, O_6, O_8, O_{12} and O_{13}) of all the four Groups. This outcome also supports the hypotheses H1, H2 and H3 as discussed earlier in this chapter.

It is significant to note that the observations obtained for right side rotation are consistent with other recovery patterns of ROM for cervical spine. The experimental Groups, Group (1, 2 and 3) highlighted in Figure 4.125 have shown better recovery as compared to control Group (Group 4). All the three experimental Groups have shown a steeper graph than control Group (Figure 4.125), suggesting better recovery for Groups 1, 2 and 3. However, some of the results are either non-significant or significant at the level of $p<.1$. This is also supported by any of the post hoc comparisons (t) among the adjusted means of ROM in right side rotation (Table 4.170 and Figure 4.101). Further, the description given in chapter-4 with respect to Figure 4.125 takes into account the linear functions derived from the total outcome of 12 days and follow-up. However, it is observed from the data that the first seven days were very crucial for the treatment, that is, the rate of change in the dependent measure was very quick during the first 7 days, and after that the curve started forming a plateau as maximum recovery had already taken place. Therefore, interpreting the outcome for the first seven days will be quite crucial. If we observe the experimental Group 1, the rise in the curvature is very steep from day 1 to day 7. For experimental Group 2, it is similar with respect to the slope function. Experimental Group 3 had slower recovery till day 6 and steep rise was seen after the administration of NAGs from day 7 onwards. Lastly, in the control Group 4, the rise has been constantly slow. This indicates that NAGs are more effective treatment in comparison to conventional methods of treatment. This is further supported by adjusted means of ROM (right side rotation) of all the relevant post hoc comparisons (t), which show that Group 4 had minimal ROM (adjusted means) as compared to other experimental Groups. This outcome also supports the hypotheses H1, H2 and H3 as discussed earlier in this chapter. A difference was observed (1) between left side and right side rotation which might have been due to right hand dominance which is observed in majority of the population, and (2) between cervical rotation and other cervical movements (flexion, extension and side flexion), which is mainly due to attainment of maximum rotation at C0- C1 level (about 50%, i.e., 45º). As per Dumas (1993), approximately 55% to 58% of the total rotation of the cervical region occurs at the atlanto-axial joint and lower cervical spine yields remaining of it.

Rotation to left side will compress the facet joint of right side and vice-versa. Unilateral NAGs given was seen to be efficient in gaining ranges. Rotation in the cervical spine is coupled with side-flexion of same side, thus, increasing the stress at inter-vertebral discs. Lewit (1985) also stated that this mechanical block caused by the inert structures within a joint can also lead to reduced joint mobility; NAGs overcome the mechanical hindrance coming from the bony segment. NAGs also release any soft tissue entrapped in facet joint, which is at higher risk due to combined coupling movement. Isometric exercises and mobility exercises were the measures to prolong the effect of NAGs and sustain the gain in range of motion.

5.3. PAIN (VAS) IN AVAILABLE END RANGE OF MOTION

The present study addresses the next sub-problem related to cervical spine pain as: ***Do NAGs reduce pain and increase range of motion simultaneously?***

To Figure out the collective effect of NAGs on pain reduction and increased ROM simultaneously, the data has been compared and the relationship has been checked between ROM (in all movements of cervical spine) and VAS (measured in available end range of motion).

VAS (Flexion) and ROM (Flexion)

Figure 4.114 exhibits the recovery patterns of VAS scores measured in available end range of flexion, of all the Groups, from day 1 to day 42. While analyzing pain (VAS scores) in flexion a highly significant difference ($p<.01$) was seen between the Groups. The subjects in different groups showed marked improvement after being treated with NAGs. The subjects in experimental Group 1 showed better recovery than those in experimental Group 2. Similarly, the subjects in experimental Groups 1 and 2 showed better recovery than those in experimental Group 3. It is pertinent to note here that control Group (Group 4), showed least recovery in terms of pain when compared with experimental Groups 1, 2 and 3. It reduces pain while doing the offending movement as it aligns back the facets into normal movement patterns. This reduction of pain also happens when sustained glide brings back joint to normal physiological positions. Reduction in pain may possibly be attributed to the fact that the accessory glide component of cervical NAGs could ameliorate pain by either separating the facet surfaces or releasing the entrapped meniscoid, or by allowing the entrapped meniscoid to return to its intra articular position, or perhaps by stretching adhesions (Hearn and Rivett, 2002). It is evident from Table 4.36 and Figure 4.34, showing the post hoc comparisons (t) among the adjusted means of VAS scores (flexion) between O_1 (pre-treatment) and O_{14} (average of 6 post-treatment observations, i.e. O_2, O_4, O_6, O_8, O_{12} and O_{13}) of all the four Groups. An increased ROM (flexion) among all the four Groups (Figure 4.120) provides a similar pattern. Flexion produces anterior tilting of vertebrae combined with lesser degree of translation, NAGs retain this physiological translation and movement followed provides tilting. Hence normal physiological pattern is restored with no or lesser pain. This pattern may get disturbed with maltracking of facet joints, increased osteophytosis in inter-body joints, meniscoid entrapment or muscle stiffness. Post hoc comparisons (t) among the adjusted means for ROM (flexion) also support it (Table 4.106 and Figure 4.69). If we draw a comparison between Figures 4.114 and 4.120, a steady fall is observed for VAS scores in available end range of motion in flexion (Figure 4.114), with simultaneous steady rise in ROM for flexion (Figure 4.120). This supports the hypothesis **H4: As the pain reduces, the range of motions improves** and the NAGs are effective not only for reducing pain in available end range (flexion) but also help in increasing ROM (flexion) simultaneously. When applied NAGs results into facet joints to normal, release meniscoid and better accessory movement brings better physiological movement.

Slow pace of recovery in Group 2 was seen after day 6 as most of the subjects reported relief from symptoms and the treatment was terminated. The little pain left was treated with the help of conventional methods. It shows that conventional therapy and placebo were also able to reduce pain but recovery is facilitated with NAGs only.

VAS (Extension) and ROM (Extension)

Figure 4.115 displays the recovery patterns of VAS scores measured in available end range of extension, of all the Groups, from day 1 to day 42. Experimental Group 1, showed better recovery than experimental Group 2. Experimental Groups 1 and 2 have better recovery than experimental Group 3. It is important to note here that control Group, i.e., Group 4 showed least recovery in terms of pain as compared to experimental Groups 1, 2 and 3, and it is quite evident from Table 4.50 and Figure 4.41 showing the post hoc comparisons (t) among the adjusted means of VAS scores (Extension) between O_1 (pre-treatment) and O_{14} (average of 6 post-treatment observations, i.e. O_2, O_4, O_6, O_8, O_{12} and O_{13}) of all the four Groups. Similar pattern has emerged as an increased ROM (extension) is observed among all the four Groups (Figure 4.121). Post hoc comparisons (t) among the adjusted means for ROM (extension) also support it (Table 4.120 and Figure 4.76). If we draw a comparison between Figure 4.115 and 4.121, a steady fall was observed for VAS scores in available end range of motion in extension (Figure 4.115), with simultaneous steady rise in ROM for extension (Figure 4.121). This supports the hypothesis H4 : As the pain reduces, the range of motions improve and the NAGs are effective not only for reducing pain in available end range (extension) but also help in increasing ROM (extension) simultaneously. Mulligan gliding of these facets creates space and devoid the osteophytes from compressing the nerves. In extension also, the accessory gliding is the same as in flexion because further gliding in extension will increase the symptoms by further loading the facet joints and further compressing the already entrapped meniscoid. Gliding it in flexion clears the passage and when no compression comes on joint or meniscoid, movement becomes pain free. NAGs mobilizations also allow the therapist to directly “attack” the painfully restricted movement, even in the acute stage, by using a movement that would normally increase the patient’s symptoms but are now pain-free or centralize the pain through the successful application of NAGs.

VAS (Side Flexion) and ROM (Side Flexion)

Figure 4.116 shows the recovery patterns of VAS scores measured in available end range of left side flexion, of all the Groups, from day 1 to day 42. Experimental Group 1 showed better recovery than experimental Group 2. Experimental Group 1 and 2 have better recovery than experimental Group 3. It is pertinent to note that control Group, i.e., Group 4 showed least recovery in terms of pain as compared to experimental Groups 1, 2 and 3, and it is quite evident from Table 4.58 and Figure 4.45 showing the post hoc comparisons (t) among the adjusted means of VAS scores (left side flexion) between O_1 (pre-treatment) and O_{14} (average of 6 post-treatment observations, i.e. O_2, O_4, O_6, O_8, O_{12} and O_{13}) of all the four Groups. Similar pattern has emerged as an increased ROM (left side flexion) is observed among all the four Groups (Figure 4.122). Post hoc comparisons (t) among the adjusted means for ROM (side flexion) also support it (Table 4.134 and Figure 4.83). If we draw a comparison between Figure 4.116 and 4.122, a steady fall was observed for VAS scores in available end range of motion in side flexion (Figure 4.116), with simultaneous steady rise in ROM for side flexion (Figure 4.122). This supports the hypothesis H4 : As the pain reduces, the range of motions improve and the NAGs are effective not only for reducing pain in available end range (left side flexion) but also help in increasing ROM (left side flexion) simultaneously.

Figure 4.117 highlights the recovery patterns of VAS scores measured in available end range of right side flexion, of all the Groups, from day 1 to day 42. Experimental Group 3 showed better recovery than experimental Groups 2 and 1. Experimental Group 1 and 2 have relatively lesser recovery than experimental Group 3. It is important to note here that control Group, i.e., Group 4 showed least recovery in terms of pain when compare with experimental Groups 1, 2 and 3, and it is quite evident from the Table 4.68 and Figure 4.50 showing the post hoc comparisons (t) among the adjusted means of VAS scores (right side flexion) between O_1 (pre-treatment) and O_{14} (average of 6 post-treatment observations, i.e. O_2, O_4, O_6, O_8, O_{12} and O_{13}) of all four Groups. The pattern of recovery towards increased ROM (right side flexion) as observed from Figure 4.123 also shows that maximum recovery occurred in Group 3 followed by control Group 4 and then other two experimental Groups, i.e., Groups 1 and 2. Post hoc comparisons (t) among the adjusted means for ROM (right side flexion) support the same (Table 4.144 and Figure 4.88). If we draw a comparison between Figure 4.117 and 4.123, a steady fall was observed for VAS scores in available end range of motion in right side flexion (Figure 4.117), with simultaneous steady rise in ROM for right side flexion (Figure 4.123). This supports the hypothesis H4 : As the pain reduces, the range of motions improve and the NAGs are effective not only for reducing pain in available end range (right side flexion) but also help in increasing ROM (right side flexion) simultaneously.

Lateral flexion is coupled with ipsilateral rotation, at the same time rotation is also coupled with ipsilateral lateral flexion. These motions also involve a combination of vertebral tilt to the ipsilateral side and translations at the zygapophyseal joints (Bogduk and Mercer, 2000; & Panjabi *et al.,* 2001). Vascular, fat-filled synovial folds project between articular surface as meniscoid inclusion, and are prone to bruising or rupture in injuries forming joint hemarthroses (Taylor and Taylor, 1996). After passive inter-vertebral accessory movements the frequency of entrapment of synovial folds readily decreases. NAGs also put zygapophyseal joints into their natural plane of motion. After NAGs with no soft-tissue entrapment there is better physiological translation at facet joint, and increased range of motion pain is less during lateral flexion in the subjects.

VAS (Rotation) and ROM (Rotation)

Figure 4.118 displays the recovery patterns of VAS scores measured in available end range of left side rotation, of all the Groups, from day 1 to day 42. Experimental Group 1, showed better recovery than experimental Group 2. Experimental Group 1 and 2 have better recovery than experimental Group 3. It is important to note here that control Group, i.e., Group 4, showed least recovery in terms of pain as compared to experimental Groups 1, 2 and 3, as is evident from Table 4.82 and Figure 4.57 which show the post hoc comparisons (t) among the adjusted means of VAS scores (left side rotation) between O_1 (pre-treatment) and O_{14} (average of 6 post-treatment observations, i.e. O_2, O_4, O_6, O_8, O_{12} and O_{13}) of all the four Groups. Similar pattern has emerged as an increased ROM (left side rotation) is observed among all the four Groups (Figure 4.124). The subjects in control Group 4 have shown lesser recovery as compared to the experimental Groups. Post hoc comparisons (t) among the adjusted means for ROM (left side rotation) also support it (Table 4.158 and Figure 4.95). If we draw a comparison between Figure 4.118 and 4.124, a steady fall was observed for VAS scores in available end range of motion in left side rotation (Figure 4.118), with simultaneous steady rise in ROM for left side rotation (Figure 4.124). This supports the hypothesis H4 : As the pain reduces, the range of motions improve and the NAGs are effective not only for reducing pain in available end range (left side rotation) but also help in increasing ROM (left side rotation) simultaneously.

Figure 4.119 exhibits the recovery patterns of VAS scores measured in available end range of right side rotation, of all the Groups, from day 1 to day 42. Experimental Group 1, showed better recovery than experimental Group 2. Experimental Group 1 and 2 have better recovery than experimental Group 3. It is pertinent to note that control Group (Group 4), showed least recovery in terms of pain when compared with experimental Groups 1, 2 and 3, as is evident from Table 4.94 and Figure 4.63 which show the post hoc comparisons (t) among the adjusted means of VAS scores (right side rotation) between O_1 (pre-treatment) and O_{14} (average of 6 post-treatment observations, i.e. O_2, O_4, O_6, O_8, O_{12} and O_{13}) of all the four Groups. An increased ROM (right side rotation) was observed among all the four Groups (Figure 4.126) presenting a similar pattern for the groups. The subjects in control Group 4 have shown lesser recovery as compared to the experimental Groups. Post hoc comparisons (t) among the adjusted means for ROM (right side rotation) also support this observation (Table 4.170 and Figure 4.101). If we draw a comparison between Figure 4.119 and 4.126, a steady fall was observed for VAS scores in available end range of motion in right side rotation (Figure 4.119), with simultaneous steady rise in ROM for right side rotation (Figure 4.126). This supports the hypothesis H4 : As the pain reduces, the range of motions improve and the NAGs are effective not only for reducing pain in available end range (right side rotation) but also help in increasing ROM (right side rotation) simultaneously.

Rotation produces compressive force on contralateral side and opening of joint space on ipsilateral side. Maltracking of the facet will produce pain. Though maximum axial rotation occurs at atlanto-axial joint but facet locking at lower cervical spine can still elicit reduced mobility and pain. NAGs unlock the facet and correct the mal-tracking of these joints. Occluding arteries may also provoke pain by local ischemic effect on muscle (Hagberg, 1984 & 1987) accessory glides given in the form of NAGs bring the motion segment to natural movement pattern and indirectly relieve the artery of occlusions. Rotation is coupled with lateral bending further enhancing the chances of lateral root compression through osteophytes. NAGs decrease the chances of lateral root compression as stated by Mulligan (1999). This technique restores the normal movement option to the joint, which may have both mechanical and neurological components.

The range of motion has also considerably increased after applying NAGs. The finding is similar to the one found in the pain levels. There was an immediate improvement in ranges when compared with pre-treatment values, and the effect was also more lasting when assessed on day 42. Better results seen with NAGs, which was due to its mechanical and neurophysiological effects (Zusman, 1985). Mechanical effects could involve a permanent or temporary change in length of connective tissues structure such as joint capsule of the zygoapophyseal joints, ligaments and muscles. It seems unlikely that any observed changes in mobility associated with mobilization are due to permanent changes in the length of connective tissues. Therelkeld (1992) suggested that the forces used in mobilization are not great enough to result in micro-failure of tissues and more likely to cause temporary length changes due to creep which is reversible over time. One of the other reasons may be modulation of afferent input such that perception of pain is diminished (Zusman, 1985).

5.4. NECK DISABILITY INDEX

The present study addresses the next sub-problem related to cervical spine pain as: ***Do the reduction in pain and increased joint range of motion improves the quality of daily living?***

Figure 4.126 presents the recovery patterns of Neck Disability Index scores of all the Groups, from day 1 to day 42. Experimental Group 1 (blue) received NAGs along with conventional physiotherapy on all twelve days of observations and the subjects in this group showed better recovery than those in experimental Group 2 (red) who received NAGs along with conventional physiotherapy only for the initial six days and only conventional physiotherapy from day 7 onwards. The subjects in experimental Groups 1 and 2 have shown better recovery than those in experimental Group 3 (green) who were treated with only conventional physiotherapy for the initial six days and NAGs along with conventional physiotherapy in the last 6 days, i.e., from day 7 to day 12. It is important to note here that the subjects in control Group, i.e., Group 4 (purple) who were treated with only conventional physiotherapy throughout the observation period, i.e., from day 1 to day 12, showed least recovery in terms of neck disability index scores as compared to those in experimental Groups 1, 2 and 3, as is evident from Table 4.184, showing the post hoc comparisons (t) among the adjusted means of NDI between O_1 (pre-treatment) and O_{14} (average of 6 post-treatment observations, i.e. O_2, O_4, O_6, O_8, O_{12} and O_{13}) of all the four Groups. Table 4.184 and Figure 4.108 show that highly significant differences existed in Groups 1 vs 3, 1 vs 4, 2 vs 3, and 2 vs 4. As pain (VAS scores) started reducing and ROM (in all directions) started increasing, the NDI scores also started showing improvement in the same pattern. It was also observed that on day 12, experimental Group 3, which received, NAGs during the last 6 days showed better recovery than control Group (Group 4), that did not receive NAGs at all. It is also evident from Table 4.180 and Figure 4.106, which show a clinically significant difference ($p<.1$) between Group 3 vs 4. Similarly, highly significant differences were seen between Groups 1 vs 4, and 2 vs 4 (Table 4.180, Figure 4.106). It is pertinent to note that no significant difference was seen between Group 3 vs 4 (Table 4.176 and Figure 4.104) till day 6, as experimental Group 3 was also not receiving NAGs like the control Group (Group 4). It is evident from Figure 4.126 that there was a steep fall in the NDI scores after the NAGs were administered to Group 3 from day 7 onwards.

It is significant to note that the description given in Chapter-4 with respect to Figure 4.126 takes into account the linear functions derived from the total outcome of 12 days and follow-up. However, it is observed from the data that the initial seven days were very crucial for the treatment, that is, the rate of change in the dependent measure was very quick during the first 7 days, and after that the curve started forming a plateau as maximum recovery had already taken place. Therefore, interpreting the outcome for the first 7 days will be very crucial. If we observe the experimental Group 1 (blue), the fall in the curvature is very steep from day 1 to day 7. For experimental Group 2 (red), it is similar with respect to the slope function. Experimental Group 3 (green) showed slower recovery till day 6, and steep fall was seen after the NAGs were administered on day 7 onwards. Lastly, in control Group 4 (purple) the fall has been constantly slow. This indicates that NAGs are more effective treatment in comparison to conventional methods of treatment.

The above discussion brings out that as pain (VAS scores) started reducing and ROM in all directions started increasing; the NDI scores also started showing improvement in the same pattern. Group 1 (receiving NAGs throughout 12 days of observation) showed better recovery than Group 2 (receiving NAGs only for the initial 6 days), followed by Group 3 (receiving NAGs only for the last 6 days), and Group 4 (receiving only conventional physiotherapy throughout the observation period). This supports the hypothesis **H5: As the pain reduces, the range of motions increase and activities of daily living also improve.**

This study addresses the next sub-problem related to cervical spine pain as: ***Do NAGs improve activities of daily living immediately in comparison to available conventional methods of treatment?***

It is observed from Figure 4.126 that experimental Group 1 (blue) and experimental Group 2 (red) receiving NAGs from the very first day had lesser disability after the treatment on day 1 itself as compared to experimental Group 3 (green) and control Group (Group 4, purple). A steep fall in NDI scores was seen in Groups 1 and 2 (Figure 4.126), along with reduction in pain (VAS scores) and increase in ROM (in all directions). The NDI scores showed almost the same recovery pattern as in VAS and ROM. Table 4.172 and Figure 4.102 support it, where highly significant differences were seen between Groups 1 vs 3, 1 vs 4, 2 vs 3 and 2 vs 4. However, this effect was lost on 2nd day in Groups 2 and 3, as some disability re-appeared, while in Groups 1 and 4 it was maintained. It is pertinent to note that again highly significant differences were observed between Groups 1 vs 3, 1 vs 4 and 2 vs 4 on day 2 (Table 4.174 and Figure 4.103) and significant difference was seen between Group 2 vs 3. On day 6 the differences between Groups 2 vs 3 increased to a high level of significance ($p<.01$) as is evident from Table 4.176 and Figure 4.104. NAGs help in reducing NDI immediately, the statement is also supported by the steep fall observed in NDI scores in Group 3 on day 7 (Figure 4.126) as the NAGs were started. However, in observation 8 (day 7, post-treatment), statistically, no significant difference was observed between Group 3 vs 4. While on day 12 clinical significant difference ($p<0.1$) was observed between Group 3 vs 4 (Table 4.180 and Figure 4.106).

The above discussion shows that as pain (VAS scores) started reducing and ROM (in all directions) started increasing immediately after receiving NAGs, the NDI scores also started showing improvement in the same pattern. Though NAGs cause immediate reduction in NDI, but these require to be continued for few days more to have a lasting effect. This supports the hypothesis **H5: As the pain reduces, the range of motions increase and activities of daily living also improve**.

The present study addresses the next sub-problem related to cervical spine pain as: ***Do NAGs have a long-term effect on activities of daily living?***

Observation 13 taken on day 42 as a follow-up assessment (Figure 4.126) shows that in experimental Groups 1 and 2, a very minimal amount of disability (NDI scores) returned as compared to day 12. However, in experimental Group 3, there was further reduction in NDI scores (though very minimal); a gross increase in NDI scores was observed in Group 4, on day 42 as compared to day 12. This is probably due to full recovery of the subjects in Groups 1 and 2 by day 12, while those in Groups 3 and 4 were still having scope for further recovery in NDI scores. On day 42, a highly significant difference was seen between Group 1 vs 4, 2 vs 4 and 3 vs 4 (Table 4.182 and Figure 4.107). It is interesting to note the results highlighted in Figure 4.107 that Groups 1, 2 and 3 had lower mean (adjusted mean) of NDI, scores i.e., lesser disability as compared to control Group (Group 4).

The above discussion leads us to say that reduction in pain and increases in ROM due to NAGs have not only shown immediate effect on neck disability management but also have a long lasting effect on it. It is also observed that in order to have a lasting effect of NAGs, it is important to give NAGs for a number of days and single treatment of NAGs will not be sufficient. This supports the hypothesis **H5: As the pain reduces, the range of motions increase and activities of daily living also improve.**

Normal pain free range of motion is essential for normal functioning of the body. This holds true for any joint in the body and for the cervical spine too. The components of NDI, viz. pain intensity, personal care, lifting, work, headaches, concentration, sleeping, driving, reading and recreation are directly related to the subjects' pain. The reduction in NDI scores observed in both the Groups may have been due to the reduction of pain and improvement in range of motion. Vernon and

Mior (1991) examined the reliability and validity of the NDI in a small number of patients and declared that the NDI seemed sensitive to change and correlated significantly with the visual analogue scale (VAS) of pain intensity. Lesser cervical pain and increased range of motion contributed in making the activities easier, hence, lowering the NDI. Pain intensity was severe in NDI followed by work and reading. Reduced pain level through NAGs must have lowered the problems encountered in reading and work as well. It causes accumulation of muscles metabolites, which lead to pain, or by compression of arteries going to occipital area. NAGs are presumed to increase circulation in joint capsule through the movement produced and this increased flow washes away the metabolites, hence, lowering the pain by eliminating nociceptive stimuli. Better and physiological plane of movement also saves the tortuous arteries from getting impinged. It was also stated by Mulligan (1999) that the success of MWM in conferring this rapid pain relief and restoration of movement is due to its ability to reduce a positional fault of the bony segment. Lesser headaches and reduced pain were indirectly helpful in improving concentration levels, hence, better reading and recreation. Better personal care scores were also seen which have further helped in realizing improvement by subjects. The significant improvement may also be attributed to the strengthening programme incorporated in the treatment. The importance of muscle strength is a major concern when rehabilitating patients with cervical dysfunction (Berg *et al.,* 1994; Hopkins and White, 1993; Saal *et al.,* 1996; Silverman *et al.,* 1991). Cervical muscles need to be strengthened as they hold up the head and neck. The cervical musculature strengthening may have also increased proximal stability to the head and neck region (Gebhard, 1994).

It was seen that proper ergonomic care is essential for a lasting effect of NAGs. The results show that there was return of symptoms to some extent in observations recorded on day 42, which may be attributed to muscular spasm that still prevails, posture of neck and hence, ergonomic awareness. In a recent research by Yip *et al.* (2008), while evaluating the relationship between head posture and neck pain; they concluded that smaller the cranio-vertebral angle (CV) more is the forward head posture leading to more pain and disability. This forward head posture has to be checked and proper postural alignment and re-education is necessary. Effect produced might prove to be short lived if neck sustains to be in same mal-posture, which might increase, mal-tracking of facet joints, hence, increasing in pain. In another study, McAviney *et al.* (2005) found that lordosis of less than 20° leads to cervical pain. Professional working with neck bending forwards will have lesser lordosis angle hence, pain will continue to persist, so proper exercises to increase lordosis and better postural care will prove extra beneficial when treated with NAGs.

The results coincide with the study done by Chhabra *et al.* (2008) to prove the effectiveness of self-SNAGs over conventional physiotherapy management in chronic neck pain among computer professionals. This study depicted that Group receiving self-SNAGs showed better carry over effect during treatment phase and more during follow-up phase as compared to Group receiving conventional physiotherapy alone. Self-gliding coupled with strengthening exercises was an effective measure in chronic management of neck pain.

5.5. ANXIETY (STAI)

This study addresses the next sub-problem related to cervical spine pain as: ***Is there any relationship between neck pain and anxiety?***

It has been observed that the differences between the Groups with respect to level of anxiety are not significant. Several studies have reported that anxiety and depression are risk factors in neck pain (Côté *et al.,* 2008; Hogg-Johnson *et al.,* 2008; & Young *et al.,* 2009). Poor psychological health has been found to be a risk factor for neck pain and is often associated with it (Hogg-Johnson *et al.,* 2008). Also, there are few studies reporting that neck pain leads to anxiety (Carroll *et al.,* 2009; Main and Watson, 1999; Narita *et al.,* 2006; Poleshuck *et al.,* 2009; Reichborn-Kjennerud *et al.,* 2002; & Rode *et al.,* 2006). Though, a decline in anxiety levels was found in all the Groups, significant differences between the Groups treated with NAGs and the placebo have not been obtained. Lower anxiety levels might be due to better ranges and decreased pain. Reduced NDI scores also help in reducing anxiety levels. This enables us to make a statement that NAGs are equally helpful with conventional physiotherapy in decreasing anxiety levels. It should also be taken into account that anxiety could also be due to other reasons than pain, like job dissatisfaction, financial strains, or other family problems. It can also be thought that patient's personality is also an important factor.

Painful and restricted ranges will have an adverse impact on psychological status. So, it has been hypothesized that with the reduction in pain and better ranges, anxiety will also be reduced. However, ANCOVA and post-hoc comparisons did not show any difference between the Groups.

It is observed from Figure 4.127 that the mean anxiety scores of all the four Groups on O_1 (pre-treatment observation) start with the highest value and as the trials progress the mean values start declining consistently as function of trials. This is observed even in the control Group where conventional methods of treatment were administered. The non-significant outcome is observed because all the four Groups show similar trend over the trials, that is, the mean anxiety scores reduced in all the four Groups as the trials progress. The curves being parallel over the trials, the F-value becomes non-significant. An important observation made from Figure 4.111 is that anxiety reduces as the subject undergoes any treatment; it is not specific to the treatment. Significant outcome in the F-value is observed when the slope is not zero. Here, we are comparing different Groups, wherein, the trend of slope function is similar, thus, a non-significant outcome.

Reduced pain and increased range of motion resulted in better NDI scores, which helped in reducing anxiety levels. Easiness in performing daily activities, such as personal care reduces the anxiety of the subjects. This enables us to make a statement that NAGs are helpful in decreasing pain and improving activities of daily living, resulting of reduction in anxiety over the trials. It is not that all the treatments have similar efficiency, the anxiety level is related to the improvement in reduction of pain and better mobility, in whatever manner (treatment) it is achieved. This supports the hypothesis **H6: As the pain reduces the range of motion increases and level of anxiety decreases.**

5.6. DEMOGRAPHIC DATA

The demographic data collected through McGill Pain Questionnaire (MPQ) has been discussed in this section.

Figure 4.1 exhibits that people in the age Group 30-40 are worst affected by mechanical neck pain. It can be due to the fact that generally the degeneration of the cervical spine starts from the age of 25-30 years. Taylor and Twomey (2000) explain that it occurs due to the effect of shearing forces in medial extension of horizontal fissures into nucleus and posterior annulus. It is more evident as transverse fissures in the posterior part of disc between two uncovertebral joints by the age of late thirties. Lesser number of people with the increasing age could be seem to have increase in degenerative changes resulting in other complications like radiculopathies and other associated symptoms, which are exclusion criteria of the study.

The study provided that more mesomorphic population complained pain and stiffness (Figure 4.2). The finding coincide with the study done by Webb *et al.* (2003) which stated that age, female gender, high body mass index and south Asian ethnicity were significant predictors of both neck & back pain with disability in a population-based study in UK.

While studying the I.Q. level of the sample population (Figure 4.3), it was found that majority of them have a good I.Q. level (4 out of 5). However, no related research was found that can comment on relation of I.Q. with pain in cervical spine. The mean I.Q. was seen to be on higher side making us conclude that people with more I.Q. are more concerned about their general well being and are more health conscious. People with lesser I.Q. do not either bother about their treatment or might be ignorant about it.

An analysis of NDI levels (Figure 4.4) revealed that pain intensity was severe as shown by the NDI scores. Restricted and painful ranges were responsible for disability in doing work like lifting and recreational activities. Flexion was the most offending movement in the sample population studied and as reading requires flexion, it was found to affect in NDI scores. Inability to move neck freely also brought restriction in personal care and driving. Headache can be the result of high anxiety levels due to the pain or as a referred pain of muscular strains. As concentration does not require movement and neck is in neutral position, it was affected to slightest effect. NDI scores reduced (lesser the scores, better the well-being of a person), as the pain decreased and range of motion increased with the progression of the treatment in all four Groups as discussed earlier in this chapter in the light of statistical data analyses.

The bar diagram (Figure 4.5) is showing lesser subjects with prolonged history of neck pain. This is because with prolonged pain these subjects have developed other complications and were kept in exclusion criteria. It can also be assumed that people had become habitual to this pain or self-learning had taught them to perform activity in this pain itself. So, this might be the reason that lesser number of subjects with a past history of more than 5 years was seen.

Most of the subjects complained pain for less than 10 days because of acute flare up or first such experience. Few people complained pain for 11-20 days, because they either waited it to subside or tried alternative therapy. There were some people who complained that the duration of present pain was between 20-30 days. This could be for the reason that they tried alternative therapy or had some sort of self-medication for the same, which might have not worked for them and it became difficult for them to bear the pain.

More number of subjects complained gradual onset of pain (Figure 4.7), which indicates that micro trauma, and postural malalignment is the cause for pain. Côté *et al.* (2000) brought out that, main causes of mechanical neck pain include minor injuries or sprains to muscles and ligaments in the neck and malalignment of facet joints. Sudden onset can be due to locked facet joints, sprain, and strains because of wrong working posture or jerk, etc.

Figure 4.8 reflects that pain in many subjects was of the “same” intensity when it started initially. Increasing intensity was less reported because people who were on medication were ruled out. The number of subjects reporting fluctuating pain was also less for the reason that they might not have bothered about it In “off” phase of pain they were anyway fine and thought that pain will subside itself in “on” phase. Those with decreasing intensity must have decided to give more time for pain to subside by itself, hence, were lesser in number.

Figure 4.9 depicts that most of the subjects complained with the progress of the day. It can be attributed as mechanical neck pain or pain due to malposture throughout the day. Active inflammation could be the reason of increased pain in the morning. A very small number of subjects, i.e., 4 out of 100 reported an increase in pain at night. A deep evaluation was done and no contra-indication was found in these cases. It is assumed that mal-positioning of neck while lying is the reason for the increasing pain in such cases. The continuous pain in the subjects might be due to severe muscular spasm/sprain and strain.

Though the VAS score was less but still the subjects termed their pain as distressing and discomforting (Figure 4.10). Reduction of work productivity and lesser concentration could be the reason for distress. Difficulty in performing their activities can be a reason of discomforting pain. The people who are more conscious about their health may report distressing pain earlier than others.

Figure 4.11 reveals that flexion was most offending movement in majority of the cases as it is the most dominant movement performed in daily activities. Unilateral rotation was not predominantly offending because of the fact that maximum of the rotation takes place at atlanto-axial joint (45^{o} on each side). Extension was seen to be painful as extension compresses the facet joint, and maltracking of these joints causes pain on movement.

While studying combined movement, it was found that bilateral side flexion was most pain producing (Figure 4.12). Side flexion creates traction at one side and compressive loads on other side. Compression of facet joints at ipsilateral side and stretch pain of spasmodic muscle at contralateral side provoke pain. Faulty coupling occurring at cervical pain may also provoke pain in extension and side flexion.

Pain in neutral position could be due to the restriction in all ranges of motion. Lying to sitting was painful because the positional change brings movement at facet joints, thus, increasing pain. Weak neck musculature can also be a cause of pain in prolonged sitting and weight bearing.

Figure 4.12 highlights the relation of posture and pain. Majority of the subjects reported relief in lying position. It might be for the reason that lying offloads the joints. Lying is also a relaxing position for the whole body, hence, provides psychological relief from pain. Another imperative fact is that in Mulligan concept, NAGs are done in weight bearing positions. Mulligan (2004) described that in non-weight bearing technique, improvements gained are lost when the patient resumes an erect posture. This is the reason why NAGs are given in a sitting posture. In some subjects, shoulder elevation relieves pain. This is because elevating shoulder is relaxing spasm from trapezius muscles.

A study of Figure 4.13 and keeping in view the most common pattern, it was observed that most of the subjects reported continuous pattern of pain. It may be because of severity of pain or experiencing it constantly in one's mind, hence, forming a continuous pattern. Subjects also complained rhythmic pattern, because activities led to pain and rest brought them relief.

Figure 4.14 demonstrates the expression of feeling of pain in the subjects under study. It can be observed that their perception of pain is different in all the cases. One thing is common across the sample that the perception of pain is uncomfortable, unpleasant, and one that interferes with the concept of well-being. As different people have expressed their pain in their own way, there is no method to check their perceptions accurately and exactly. Hence, it is difficult to comment why they experienced different types of pain.

The overall results of the study showed highly significant improvement in pain, range of motion and Neck Disability Index in Groups treated with Mulligan concept at the end of 12 days of the intervention. The effect gained was sustained on day 42 also. The subjects in different groups treated with NAGs showed better results in terms of pain, range of motion, and Neck Disability Index.

The results of the study are consistent with those of systematic review done by Hurwitz *et al.* (2008). They concluded that the best evidence synthesis suggests that therapies involving manual therapy and exercise are more effective for patients with neck pain.