Introduction:
Stroke is a leading cause of long-term disability in the Western world, with a prevalence of approximately 900 per 100,000 persons. Because of remarkable development in the acute management of stroke, the majority of patients now survives and recovers, experiencing only a modest decrease in life expectancy. In Bangladesh we do not know the actual prevalence and impact of stroke but it may approximate or exceed the statistics of the western world.

During the last decade, the number of stroke survivors has increased 30 percent worldwide. As a result considerable number of stroke survivors present with partial to complete loss of function and social burden. Though the incidence of stroke doubles with each decade beyond 60 years of age, the incidence of stroke has increased dramatically in younger individuals in the recent years. This changing landscape for persons surviving stroke underscores the critical importance of providing effective rehabilitation with the potential to optimize recovery of function, minimize long-term disability, and enable functional independence so that quality of life and employment is ensured. In a poor country like Bangladesh the socioeconomic burden of disabled stroke survivors is much higher. We need to bring these young disabled into mainstream of development.

The sequel of stroke: The sequelae of stroke are multifactorial and depend heavily on the mechanism, extent, and location of the vascular lesion. The primary concern addressed in physical rehabilitation is restoration of the requisite motor function to perform the myriad of tasks encountered in daily life. These tasks range from grasping, reaching, and manipulation to more physical demanding transitional movements and complex coordinated movements, such as locomotion. Common to these motor tasks is control of muscular force, which becomes compromised with central nervous system damage and manifests as impaired intersegmental coordination, hyperreflexia or spasticity, and unilateral weakness.

Traditional perspectives: Spasticity presented the most significant limitation to recovery of normal motor function. Physical exertion was clinically observed to exacerbate spasticity. Therapeutic activities using forceful contractions became restricted for persons with nervous system injury. One prominent approach to treatment of adult
hemiplegia thus centered on the concept of managing muscle hypertonia. The general goal of neurorehabilitation treatment is to focus on improving control and especially the quality of movement. Meta-analyses that examined the effects of commonly used interventions for rehabilitation of both the upper and lower limb in poststroke hemiplegia reported a lack of compelling evidence that any of the existing approaches to neurorehabilitation have demonstrated superior efficacy for promoting recovery of motor function.\textsuperscript{4, 5}

Resistance training: Currently emerging evidence suggests that paresis may be directly responsible for compromised motor function.\textsuperscript{6-8} Positive effects of resistance exercise have been demonstrated in persons with poststroke hemiplegia, and in some cases, concomitant influences on performance of functional tasks have been observed. High-intensity activities, including resistance training, could form an important component of rehabilitation programs for persons with poststroke hemiplegia.

Muscle weakness is a common impairment after stroke. However, facilitation treatment models have often emphasized the management of spasticity without addressing underlying muscle weakness. Another common intervention focus is functional training, sometimes without addressing the contributing impairments. Lower-extremity muscle strength has been correlated with gait speed in stroke patients.\textsuperscript{9} Additionally, lower-extremity muscle strength on admission to rehabilitation is a predictor of function at discharge.\textsuperscript{10} Lower-extremity strength has also been inversely correlated with a risk of falling in elderly individuals. The recommendation for including strengthening in the acute rehabilitation of patients with muscle weakness after stroke is based on Working Group Consensus, considering the positive relationship between muscle strength, function and prevention of falls. Researchers in strength training of post-stroke patients have studied subjects after acute rehabilitation had been completed (greater than 6 months after stroke) and demonstrated improvement in muscle strength and function with training.\textsuperscript{11, 12} There is a lack of research on specific strength training during acute rehabilitation.\textsuperscript{13}

Role of agonists and antagonists in functional improvement

Weakness following stroke is referred to as either hemiparesis (mild to moderate degree of weakness) or hemiplegia (severe or complete loss of motor function) on one side of the body. However, evidence is now emerging that weakness also occurs on the ipsilesional side (traditionally termed the “nonparetic”), within a short time frame post-acute stroke.\textsuperscript{14} In the literature, poststroke weakness has been described not only as impaired force magnitude, but also as a more broadly defined phenomenon, including slowness to produce force effectively within the context of a task.\textsuperscript{15-19} Co-contraction of antagonist muscles has also been found to interfere with force magnitude, rate of force production and intersegment coordination by acting as an “antagonist restraint.”\textsuperscript{20} Significant impairment of agonist activation has been demonstrated in the paretic limb.\textsuperscript{7, 22} Such observations lead predictably to questions of whether and how agonist activation can be improved and whether such improvement in physiologic function leads to clinically and functionally important differences in motor performance.

Post-stroke paresis and functional impairment

Post stroke hemiplegia is associated with significant impairments of motor function that are believed to compromise activity of daily living (ADL) performances and lead to loss of independence. However, a direct causal relationship between strength or weakness and motor function has not been established. Traditionally, a strong bias has existed against quantifying strength in hemiplegic persons. As a result, the majority of clinical research in this population has focused on outcome measures at the activity and participation levels.\textsuperscript{23} Bohannon and Andrews observed that gait performance in 17 hemiparetic persons was significantly correlated with knee extensor torque but not with spasticity and knee extension muscle performance measured either isometrically or isokinetically correlated significantly with gait.
velocity\textsuperscript{24}. Nakamura and coworkers also observed that spasticity was unrelated to locomotor impairments\textsuperscript{25, 26}. Isokinetic knee extension strength in the paretic limb was strongly associated with self-selected walking speed (SSWS). Lindmark and Hamrin observed a moderate relationship between SSWS and either motor scores or knee extension torque, which improved in predictive power when examined in a multivariate statistical model\textsuperscript{27}. Pohl and coworkers observed that the combination of peak isometric knee extension force and rate of force acquisition explained a significant 12 percent of variance related to gait speed in hemiparetic adults\textsuperscript{28}. When plantar flexion strength was added to the model, its explanatory power increased such that it became possible to predict maximal gait speed\textsuperscript{29}. Each of the investigations just described focused on isolated muscle groups or actions. However, functional movement involves simultaneous activation and coordination of multiple muscles. This disparity may contribute in part to failure to demonstrate a direct relationship between strength and function\textsuperscript{30}.

**Strengthening Exercise Induces Neurological Recovery.**

Because poststroke weakness involves both neural and muscular changes, it seems appealing to suggest an analogy with other physiological conditions, such as aging, for which very clear benefits of strength training have been demonstrated\textsuperscript{31}. Currently, available evidence regarding strengthening in hemiplegia indicates that significant strength gains are attainable in persons with poststroke hemiparesis at acute, subacute, and chronic stages of recovery\textsuperscript{32, 33, 34}. However, the physiological mechanisms responsible for these therapeutically induced improvements have not been demonstrated. Strengthening exercises may influence neural drive at either the supraspinal or spinal level.

**Power reaching or skilled reaching training**

Recent efforts for stroke rehabilitation have been directed toward functional and task-specific therapies that focus primarily on ADL and on grossly related precursor activities\textsuperscript{35, 36}. A common element to these more recent approaches is substantially increased therapeutic intensity relative to traditional approaches. Increased intensity is defined by a substantially increased volume of therapeutic participation\textsuperscript{37} an increased amount of direct participation in therapeutic activities, or performance of activities at a higher level of the subject's functional capacity\textsuperscript{38}. Exercise dose in a stroke unit is variable and can be predicted by age and disability. Increased exercise dose is associated with improved mobility outcomes\textsuperscript{39}.

Current controversy thus centers on whether the critical variable for therapeutic efficacy is the task specificity or the intensity of effort involved in therapeutic activities. Thus, while skill-based, task-specific interventions clearly promote important use-dependent cortical reorganization, resistance training apparently can promote additional, beneficial plasticity elsewhere in the neuraxis. In all likelihood, the most effective therapeutic intervention involves a combination of elements.

**The Ultimate Goal of Rehabilitation**

The ultimate goal of rehabilitation following stroke is to promote improvements in function, activities, and participation. Collective efforts are thus required to design effective and efficient rehabilitation interventions. Weakness is not the only impairment in poststroke hemiplegia but weakness plays a significant contributory role to motor disability. By examining the various facets of weakness such as low force production, fatigability, excessive sense of effort, ineffective task-dependent force production etc. we can understand the specific nature of motor impairment and can identify potential strategies to mitigate its effects, functional improvement and participation in activities.

**Future research:**

Important area for future research is developing a greater understanding of the mechanisms underlying poststroke weakness. Without this information, we are restricted in our efforts to design appropriate rehabilitation interventions to counteract compromised function associated with poststroke weakness. Recent research evidence indicates that “task-specific” therapy\textsuperscript{40-43} produces superior outcomes as compared to traditional therapeutic approaches\textsuperscript{44-47}. In elders, strength training has
been demonstrated to decrease depression and improve sleep patterns, influence bone mass, decrease insulin resistance (Type II diabetes), and normalize blood pressure. However, there is also evidence that increased intensity of therapy leads to more significant functional outcome. There is a need to establish the effectiveness of strength training in relation to task-specific therapies because it may be the case that strength training is an efficient means for delivering high-intensity therapy. To define and implement suitable protocols of strength training into stroke rehabilitation programs, future research should explore the specific factors such as the types of exercise, the frequency, intensity and time spent in strength training, and the number of specific exercises. Moreover, the long-term effects, both long-term training and retention of training, need to be understood. Finally, once gains in strength have been achieved we need to understand how they translate to functional gains and how they are best maintained.

Precaution: One must recognize that post stroke resistant training may not be suitable for all hemiparetic persons. In this regard, we recommend exercise should be individualized on clinical judgment appropriate for any rehabilitation setting. High-intensity resistance training is certainly contraindicated in any case before the patient is neurologically stable. Other significant contraindications would involve postsurgical patients and persons with severe osteoporosis, acute orthopaedic or joint injuries. While the patient or client is exercising, his or her blood pressure should be monitored, and precautions should be taken to avoid conditions leading to a valsala maneuver.

**Conclusion:**
While the number of studies is limited, emerging evidence suggests that persons with poststroke paresis can improve strength through resistance exercise in the absence of negative side effects, including exacerbation of hypertonia. Moreover, these improvements in strength appear to transfer to functional improvements. Despite increases in strength, improvements in functional performance may not occur in hemiplegic persons with low strength and low performance. It is entirely possible that vigorous strength training promotes positive effects on other aspects of physiologic function in this type of at-risk population. Still, many unresolved issues remain. The potential for strength training to improve the overall outcomes of rehabilitation for persons with poststroke hemiplegia warrants further investigation.

**References:**
10. Andrews AW, Bohannon RW. Discharge function and length of stay for patients with


