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# AGE-RELATED DIFFERENCES IN THE MOVEMENT PATTERNS OF ADOLESCENTS 11, 14, AND 17 YEARS OF AGE RISING TO STANDING FROM SUPINE ON A BED

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# AGE-RELATED DIFFERENCES IN THE MOVEMENT PATTERNS OF ADOLESCENTS 11, 14, AND 17 YEARS OF AGE RISING TO STANDING FROM SUPINE ON A BED

A thesis submitted in partial fulfillment of the requirements for the Degree of Master of Science at Medical College of Virginia Campus/Virginia Commonwealth University

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Abstract

AGE-RELATED DIFFERENCES IN THE MOVEMENT PATTERNS OF ADOLESCENTS 11, 14, AND 17 YEARS OF AGE RISING TO STANDING FROM SUPINE ON A BED

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The purposes of this study were to determine: 1) if movement patterns (MPs) described for young adults rising from bed depict adolescents' MPs, 2) if there are age-related differences in MPs adolescents use to perform this task, 3) most common MP combinations (MCMPCs) of each age group, and 4) if individuals are likely to progress through proposed sequences in the same order.

Sixty 11-, 14-, or 17-year-olds were videotaped during 10 trials of rising. MPs demonstrated in each of four body regions were classified, and MP frequencies and MCMPCs were determined.

One new "near" arm MP was observed. Age-related MP differences were present in each region. The MCMPCs observed in 11-, 14-, and 17-year-olds were described. One MP combination was common across all groups. Subjects varied among MPs that were not proposed to be adjacent developmental steps.

MP categories developed to describe adults' movements can be used to describe adolescents' movements. MPs used by adolescents getting out

of bed differ with age. Therapists can select age-appropriate MPs when teaching this activity.

# Chapter I

## Introduction

Getting out of bed is an activity performed by most individuals at least once a day. Physical therapists frequently evaluate this activity in persons with motor impairments. The ability to get out of bed is included in several functional assessment indices, including the Katz Activities of Daily Living Index Report (Katz, Downs, Cash, & Grotz, 1970), the Kenny Self-Care Index (Schoening et al., 1965), the Linn Rapid Disability Rating Scale (Linn, 1967), and the Functional Status Index (Jette, 1985). In each of these indices, an ordinal level of measurement is used to indicate how much assistance a person requires to get out of bed or the extent to which a person is confined to bed. The movement patterns used when getting out of bed are not the focus of these assessments.

Sarnacki (1985) recently described the movement patterns used by healthy adults to get out of bed. Thirty-five young adults were videotaped during 10 trials of coming to standing from supine on a bed. The movement patterns observed in each of four body regions were described in writing. These four body regions were the right upper extremity, the left upper extremity, the head and trunk, and the

lower extremities. Based upon the movement pattern variability observed within an individual, the descriptions of movement patterns were then ordered into hypothesized developmental sequences. Whether the movement patterns used to get out of bed vary with age, however, has not been verified.

Adolescence is an important transitional period between childhood and adulthood (Katchadourian, 1977). Derived from the Latin word "adolescere," adolescence means "to grow up" (Morris, 1976). Consistent with the many physical and psychosocial changes occurring during adolescence, motor abilities also undergo change.

Several researchers, including Clarke (1971), Dimock (1935), and Espenschade (1940), have documented quantitative changes in motor abilities that occur during the second decade of life. Such age-related changes occurred in broad jumping or throwing distances, running speed, or the number of push-ups a person could complete. Fewer researchers have examined changes in the movement patterns used to perform a task. Longitudinal studies of movement pattern changes in adolescents have been limited to sport activities such as throwing (Halverson, Roberton, & Langendorfer, 1982; Roberton & Langendorfer, 1979) and hopping (Halverson, Roberton, & Harper, 1973; Roberton & Halverson, 1984).

Physical therapists frequently teach adolescents with motor impairments activities such as rolling, getting out of bed, and coming to standing from a seated position on a chair or a supine position on the floor. As part of a growing body of research examining age-related differences in the movement patterns used to perform such tasks, Boucher (1988) examined the movement patterns used by adolescents to roll from supine to prone. Seventy healthy teen-agers were videotaped during

ten trials of rolling. The movements demonstrated were classified using movement pattern descriptions developed in a previous study of young adults (Richter, 1985). The movement patterns used to roll varied with age across the teen years (Boucher, 1988). Whether age-related differences occur in the movement patterns used by adolescents to perform other functional activities, such as getting out of bed, is not known.

The main purpose of the present study was to determine if there are age-related differences in the movement patterns exhibited by adolescents when coming to standing from supine on a bed. A second purpose was to determine if descriptions of the movement patterns used by young adults when rising from supine on a bed (Sarnacki, 1985) are comprehensive descriptions of the movements used by adolescents performing the same task. A third purpose was to describe the most common form of rising used by adolescents to rise to standing from supine on a bed. The final purpose, of theoretical interest, was to determine if individual patterns of variability in the movements used to get out of bed were consistent with a hypothesis that all individuals would progress through the proposed developmental sequences in the same order.

Physical therapists need to be aware of the movement patterns that adolescents use to get out of bed. When evaluating patients, clinicians are interested in both if patients can perform an activity and the movements used. Both types of information are used to identify functional impairments, establish realistic treatment objectives, and plan appropriate treatment activities. If therapists are aware of the movement patterns that able-bodied adolescents use to get out of

bed, they can better identify abnormal patterns in disabled adolescents and teach the activity using age-appropriate movement patterns.

## Research Questions

Main question. Are there age-related differences in the movement patterns exhibited by adolescents when rising to standing from supine on a bed that correspond to developmental sequences proposed from a previous study of young adults (Sarnacki, 1985)?

Sub-question. Are descriptions of the movement patterns used by young adults when rising to standing from supine on a bed comprehensive descriptions of the movement patterns used by adolescents performing the same task?

Question two. What is the most common combination of right upper extremity (RUE), left upper extremity (LUE), head and trunk (HT), and lower extremity (LE) movement patterns used by each age group of adolescents to rise to standing from supine on a bed?

Question three. Does individual variability in the movement patterns used to rise to standing from supine on a bed support the hypothesis that all individuals progress through the proposed developmental sequences in the same order?

## Operational Definitions

For the purposes of this study, the following terms were defined:

1) Movement Patterns are the spatial and temporal characteristics of positional change (Wickstrom, 1983) within a body region. The movement patterns of concern in the present study were identified in a previous study of young adults (Sarnacki, 1985). These movement

patterns are listed and described in detail in Tables 1-4 on pages 15 to 18 and illustrated in Figures 1 to 5 on pages 19 to 23.

2) Adolescents are individuals in the second decade of life, 10 to 19 years of age (Katchadourian, 1977). Subjects in the present study were 11, 14, or 17 years of age.

3) Developmental Sequences represent orderly and predictable changes over time in motor behaviors (Wickstrom, 1983). The developmental sequences examined in the present study are comprised of series of movement patterns, one for each of four body regions. In Tables 1 to 4 on pages 15 to 18, the sequences are described. These sequences had been hypothesized by Sarnacki (1985) to represent the order of motor pattern development.

## Assumptions

The following assumptions were made in the present study:

1) Motor development is related to age.

2) Motor development occurs in an orderly sequence.

3) Adolescents demonstrate intra-individual variability in the movement patterns used to get out of bed.

4) The movement patterns described for young adults getting out of bed to the right and the developmental sequences hypothesized (Sarnacki, 1985) are also applicable to individuals getting out of bed to the left.

## Limitations

The following were identified as limitations of this study:

1) Since this study was cross-sectional, the results depict age-related differences. Developmental change can only be demonstrated in a longitudinal study.

2) The results of this study may not be applicable to adolescents from cultures where the use of a bed is uncommon.

## Organization of the Remaining Chapters

Four additional chapters follow this introduction. In Chapter 2, a review of pertinent literature is presented. The procedures used in this study are detailed in Chapter 3, Methods. The results of this research are contained in Chapter 4. In Chapter 5, the results are discussed, conclusions are drawn, and the implications of this study and recommendations for future studies are presented. Chapter 5 ends with a brief summary of the current study. In Appendix J, this research is summarized in the form of a publishable article.

## Chapter II

## Literature Review

Literature from three major areas related to the present study is reviewed in this chapter. The first area addresses the functional activity of rising to standing from supine on a bed. Writings related to adolescent motor development are reviewed next, followed by a discussion of cross-sectional versus longitudinal developmental research designs.

### Rising to Standing From a Bed

Functional activities refer to purposeful body movements performed by most individuals. Examples of functional activities include getting out of bed, coming to standing from sitting on a chair or lying on the floor, rolling, or walking. When physical therapists evaluate functional activities, knowing both if a patient can perform an activity and the movements used are important. Such information is needed to establish realistic treatment objectives and to design appropriate treatment activities utilizing age-appropriate movement patterns.

For example, if a therapist was evaluating a person's gait, lower extremities that were widely abducted and upper extremities that were abducted at the shoulders and flexed at the elbows would be expected if

the individual was 12 months old (McGraw, 1940). This gait pattern would be abnormal if an individual was 17 years of age. A 17 year old patient would likely want to learn to walk with a smaller base of support and with upper extremities extended beside the trunk and moving reciprocally with the lower extremities, a more age-appropriate gait pattern. Although both individuals may be able to walk, the infant would not require gait training; the adolescent would benefit from physical therapy intervention to change the movement patterns used during gait.

In the following sub-sections, several topics are reviewed. After functional scales which can be used to assess a patient's ability to get out of bed are summarized, descriptions in the rehabilitation literature of the movement patterns used to get out of bed are examined. Research conducted on the movement patterns used to get out of bed is reviewed last.

Getting out of bed as an item in functional assessment scales. Functional assessment scales are frequently used by health care professionals to assess the physical function of patients. Jette (1985) presented a review of several commonly used functional scales. His purpose was to illustrate some of the many existing scales and to critically analyze their strengths and weaknesses. Four of those scales explicitly test the ability to get out of bed. These are the Katz Activities of Daily Living Index Report, the Kenny Self-Care Index, the Functional Status Index, and the Linn Rapid Disability Rating Scale.

In each of these scales, an ordinal level of measurement is used to indicate one's ability to get out of bed. In the Katz Activities of Daily Living Index Report (Katz et al., 1970) and the Kenny Self-Care

Index (Schoening et al., 1965), the ability to get out of bed is scored using three and five point scales respectively, indicating the amount of physical assistance required. In the Linn Rapid Disability Rating Scale (Linn, 1967), an individual is identified as being confined to bed "not at all, part of the day, or all the time" (p. 212). In the Functional Status Index (Jette, 1985), getting out of bed is evaluated using five to seven point scales based upon the amount of assistance required, the extent of pain, and the degree of difficulty.

Although an individual's ability to perform the activity is evaluated in each of these assessment scales, no information is provided about the movement patterns used to perform the task. When evaluating patients, establishing treatment goals, and implementing treatment programs, quantitative and qualitative information is essential for the physical therapist.

Descriptions of coming to standing from supine on a bed and implications for treatment. Few descriptions of the movement patterns used by able-bodied individuals to get out of bed were found in the rehabilitation literature. Carr and Shepherd (1987) in their text on motor relearning following a stroke described getting out of bed as follows: "Most people, when they sit up over the side of the bed, go from supine to sitting up, use the hands for leverage and swing the legs over the side of the bed. The elderly often turn to one side first, use their hands to push themselves up, then swing the legs over the side" (p. 84).

The authors did not provide research support for their descriptions of the movement patterns used to get out of bed. Nor did they acknowledge that there may be a great range of individual variability in

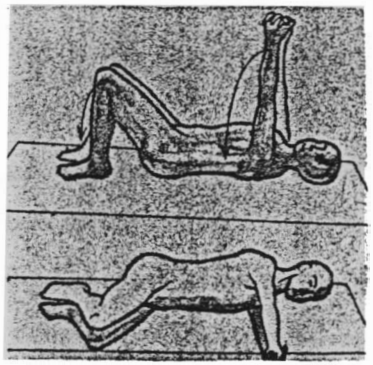
the movement patterns used to get out of bed. Although Carr and Shepherd stated that the elderly often get out of bed differently than "most" people, they did not clarify the population to which the elderly were compared. The authors did not suggest that there may be differences in the movement patterns of other groups besides the elderly.

In discussing treatment, Carr and Shepherd (1987) instruct therapists to teach patients to come to sitting from the sidelying position. The authors remark that one problem therapists may need to correct is a patient's tendency to pull on the edge of the bed instead of laterally flexing the neck and trunk when moving from supine to sitting.

Bobath (1978) discussed how to teach an individual who has had a stroke to move from a supine to standing position. Persons assisting the individual are instructed to teach the patient to clasp both hands overhead, bend both knees so the feet are on the bed, and with the knees together begin to roll by first turning the trunk and then the pelvis.

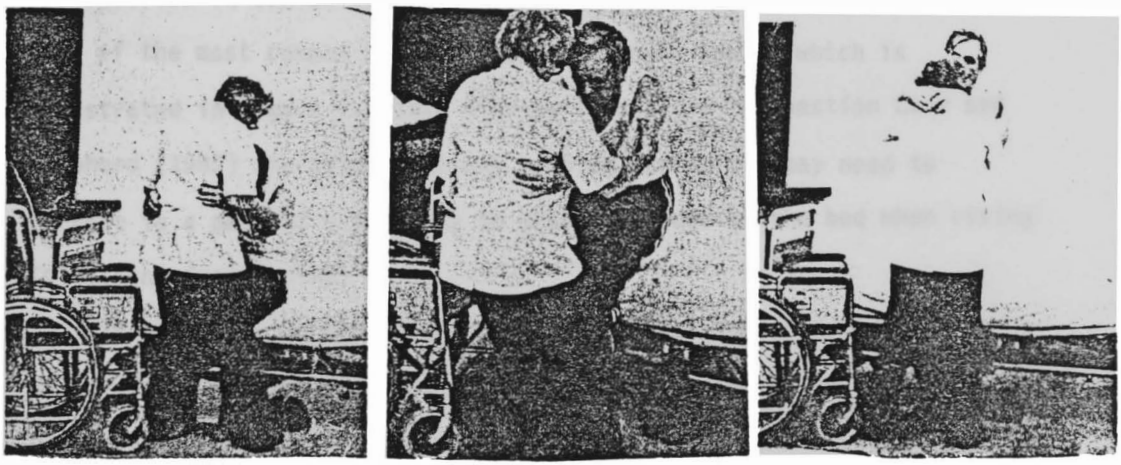
When coming to standing from supine on a bed, the patient is instructed to place both arms around the waist or on the shoulders of the person providing assistance (see Figure 6). Bobath did not provide a description of the movement patterns used to get out of bed by individuals without movement disorders. The change of abnormal patterns of movement to normal patterns of movement is, however, a stated treatment goal.

Since getting out of bed is a task taught by clinicians, clarification of these ambiguities is important. In the present study, the movement patterns used by adolescents to get out of bed have been



a) Supine to Sidelying

b) Sidelying to Sitting



c) Sitting to Standing

Figure 6. Assisting a Person With Hemiplegia to Get Out of Bed.
(From Bobath, B. (1978). Adult hemiplegia: Evaluation and treatment (2nd ed.) (pp. 76-77, 81). London: William Heinemann Medical Books.)

identified, individual patterns of variability examined, and developmental sequences hypothesized in a study of young adults (Sarnacki, 1985) tested.

Research on coming to standing from a bed. Sarnacki (1985) described the movement patterns used by healthy young adults to rise to standing from supine on a bed. In addition, she hypothesized movement pattern developmental sequences for each of four body regions.

Sarnacki's findings reinforce the importance of research in which the movement patterns used by healthy individuals to perform various functional activities are described. For example, grasping the edge of the bed was the most common right upper extremity movement pattern and was observed in 59% of the subjects. This movement pattern was also part of the most common form of rising in young adults which is illustrated in Figure 7. This finding causes one to question Carr and Shepherd (1987) who state that one problem therapists may need to correct is a patient's tendency to grasp the edge of the bed when rising to sitting from supine.

In addition, Bobath (1978) stated that changing abnormal movement patterns to "normal" movement patterns should be the aim of treatment. However, clasping both hands overhead or bending both knees with the feet on the bed were not movement patterns used by healthy young adults to get out of bed. Nor did all individuals begin to get out of bed by first rotating the trunk and then the pelvis. Sarnacki (1985), however, identified several movement patterns commonly used to get out of bed by healthy individuals that had not previously been described.

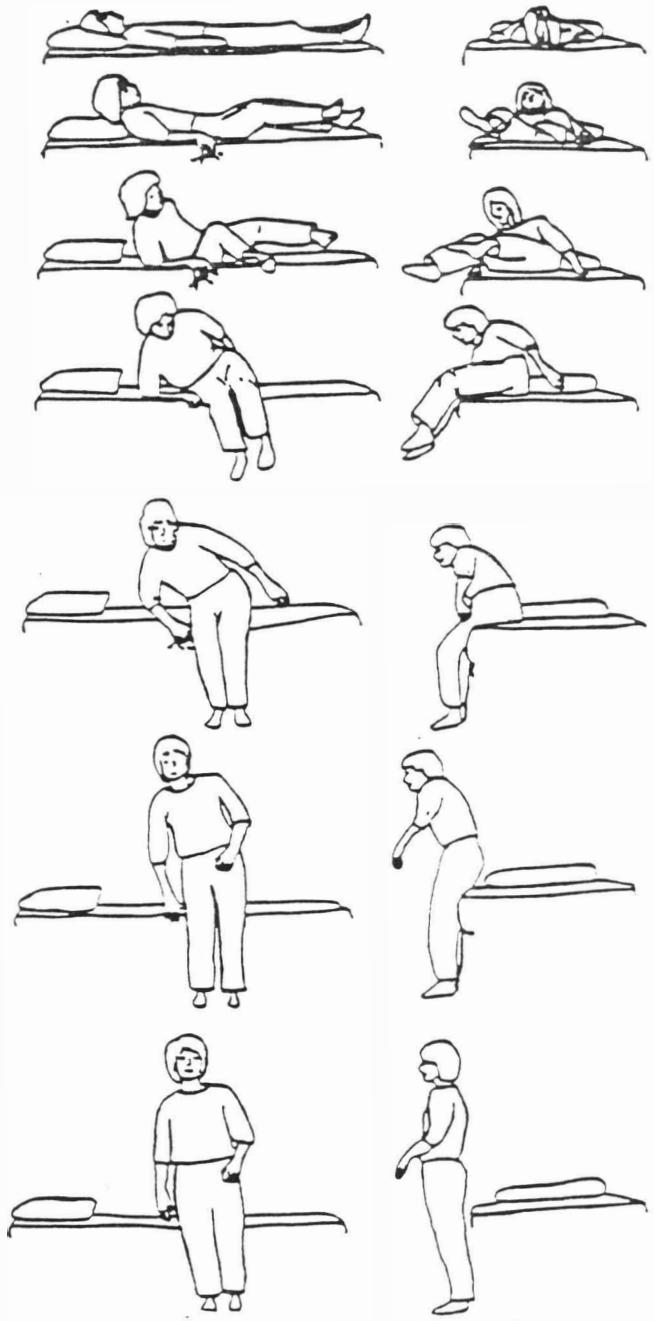



Figure 7. Most Common Movement Pattern Combination of Young Adults Getting Out of Bed (From Sarnacki, 1985).

In Sarnacki's (1985) study, thirty-five, 20 to 33 year old adults were filmed during 10 trials of getting out of bed. Focusing on a single body region, the movement patterns observed across all trials were described in writing. After grouping these descriptions based upon their similarities and differences, several general descriptions of movement patterns were formed for each of four body regions. The movement patterns demonstrated by the subjects on each of their trials were then classified using these descriptive categories. The incidence of each movement pattern was determined across all subjects and trials.

The patterns identified in Sarnacki's (1985) study are listed and described in Tables 1 to 4 and illustrated in Figures 1 to 5. All movement patterns are illustrated in these figures except the Lateral Lift and Push Pattern for the "Far" Upper Extremity.

Sarnacki originally considered the upper extremities (UEs) as a single body region. Because two camera views were required to view both extremities, however, movement pattern descriptions were difficult to form for the UEs as a single region. The UEs were, therefore, considered two separate body regions, the near upper extremity (NUE) and the far upper extremity (FUE). The "near" UE refers to the arm closest to the side of the bed toward which the individual is rising. The "far" UE refers to the arm away from the side toward which the individual is rising. For example, if one gets out of bed toward the left, the left UE is the "near" UE; the right UE is the "far" UE.

Using two concepts derived from stage theory, universality and intransitivity, Sarnacki hypothesized developmental sequences for the movement patterns of each body region. Universality means that all

Table 1

Far Upper Extremity Movement Patterns

---

1) Lateral Lift and Push: The upper extremity lifts or slides on the supporting surface toward the head of the bed. The entire upper extremity, or some part of it, is placed on the bed and pushes. The extremity extends until the hand is the only part of the upper extremity remaining on the bed. The hand lifts and the extremity may be used as a balance assist.

2) Push: The entire upper extremity, or some part of it, pushes into the bed. The upper extremity extends until the hand or elbow is the only part of the upper extremity remaining on the bed. The hand or elbow lifts and the extremity may be used as a balance assist.

3) Double Push: The entire upper extremity lifts toward the head of the bed and pushes or pushes into the bed without lifting. The extremity extends until the hand or elbow is the only part of the upper extremity remaining on the bed. The hand or elbow lifts, and the hand is placed on the bed, usually near the edge, and pushes. The hand lifts and the extremity may be used as a balance assist.

4) Lift and Push: The upper extremity lifts off the bed and may reach across the body. The hand is placed on the bed on the same side of the body at some point between the starting position and the edge of the bed and pushes. The hand lifts and the extremity may be used as a balance assist.

5) Lift or Lift and Reach: The upper extremity lifts off the bed and may reach across the body. The extremity may be used as a balance assist.

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Note. From Sarnacki (1985). A lettering system was used in Sarnacki's study to identify these movement patterns. The movement patterns are listed here in the order in which Sarnacki proposed the patterns would develop. Pattern 1 was expected to predominate prior to pattern 2. Pattern 2 was expected to predominate prior to pattern 3, and so forth.

Table 2

Near Upper Extremity Movement Patterns

1) Lateral Lift and Push: The upper extremity lifts or slides on the supporting surface toward the head of the bed. The entire upper extremity is in the extended or nearly extended position, and the hand is the only part of the extremity remaining on the bed. The hand lifts, and the extremity may be used as a balance assist.

2) Grasp and Push: The upper extremity slides or lifts to position the hand to grasp the edge of the bed. The entire upper extremity, or some part of it, pushes down on the bed while the hand grips on the edge. The upper extremity lifts and may be used as a balance assist.

3) Push: The entire upper extremity, or some part of it, pushes into the bed. The extremity lifts from the bed and may be used as a balance assist.

Note. From Sarnacki (1985). A lettering system was used in Sarnacki's study to identify these movement patterns. The movement patterns are listed here in the order in which Sarnacki proposed the patterns would develop. Pattern 1 was expected to predominate prior to pattern 2. Pattern 2 was expected to predominate prior to pattern 3.

Table 3

Head and Trunk Movement Patterns

| |
|---|
| 1) Pelvis Leading: The lower trunk rotates to the side. At sidelying, the upper side of the pelvis drops to the bed, and the trunk lifts and turns toward side facing. The subject may be in a symmetrical sitting posture before standing. |
| 2) Lateral Roll: The head and trunk turn toward the side facing position with minimal flexion toward the foot of the bed. In the side facing position, one buttock is off the bed, and the shoulders and pelvis are aligned and displaced toward the head of the bed. Just before the buttock comes off the bed, the head and trunk are displaced toward the head of the bed through lateral flexion and/or rotation. |
| 3) Roll-Off: The head and trunk flex and turn toward side facing with the weight shifted to one buttock. In the side facing position, the pelvis may drop to a level position. Just before both buttocks come off the bed, the head and trunk are displaced toward the head of the bed through lateral flexion and/or rotation. |
| 4) Come to Sit: The head and trunk flex symmetrically or flex and turn toward side facing by pivoting on one or both buttocks. If the trunk pivots on one buttock, the pelvis may drop to a level position before standing. Just before both buttocks come off the bed, the trunk is in a symmetrical sitting posture, though it may be flexed forward. |

Note. From Sarnacki (1985). A lettering system was used in Sarnacki's study to identify these movement patterns. The movement patterns are listed here in the order in which Sarnacki proposed the patterns would develop. Pattern 1 was expected to predominate prior to pattern 2. Pattern 2 was expected to predominate prior to pattern 3, and so forth.

Table 4

Lower Extremity Movement Patterns [a]

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1) Step-Off: The lower extremities are lifted asynchronously off the bed. The far extremity may push on the bed before lifting. The far extremity flexes toward the chest such that the thigh is above the near extremity thigh. The feet are usually placed on the floor asynchronously, and the near extremity may begin to extend before the far extremity foot is placed on the floor.

2) Asynchronous With Leg Extension: The lower extremities are lifted asynchronously off the bed. The far lower extremity may push on the bed prior to lifting. The thighs remain parallel as they move across the bed. The far lower extremity may be extended as it moves across and over the edge of the bed. The far lower extremity foot is in front of the near lower extremity leg as the legs descend toward the floor. The feet are placed on the floor, and the lower extremities extend to the upright position.

3) Asynchronous: The lower extremities are lifted asynchronously off the bed. The far lower extremity may push on the bed before lifting and is usually medially rotated. The thighs are parallel as they move across the bed, and the legs are parallel as they descend toward the floor. The feet are placed on the floor simultaneously, and the lower extremities extend to the upright position.

4) Synchronous: The lower extremities are lifted or slid simultaneously off the bed. A brief push on the bed may proceed the lifting. The lower extremities move together over the edge of the bed. The feet are placed on the floor simultaneously. The lower extremities extend to the upright position.

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Note. From Sarnacki (1985). A lettering system was used in Sarnacki's study to identify these movement patterns. The movement patterns are listed here in the order in which Sarnacki proposed the patterns would develop. Pattern 1 was expected to predominate prior to pattern 2. Pattern 2 was expected to predominate prior to pattern 3, and so forth.

[a] Since the side-view camera was positioned closest to the subject's right side in Sarnacki's study, the "far" extremity is the left lower extremity; the "near" extremity is the right lower extremity.

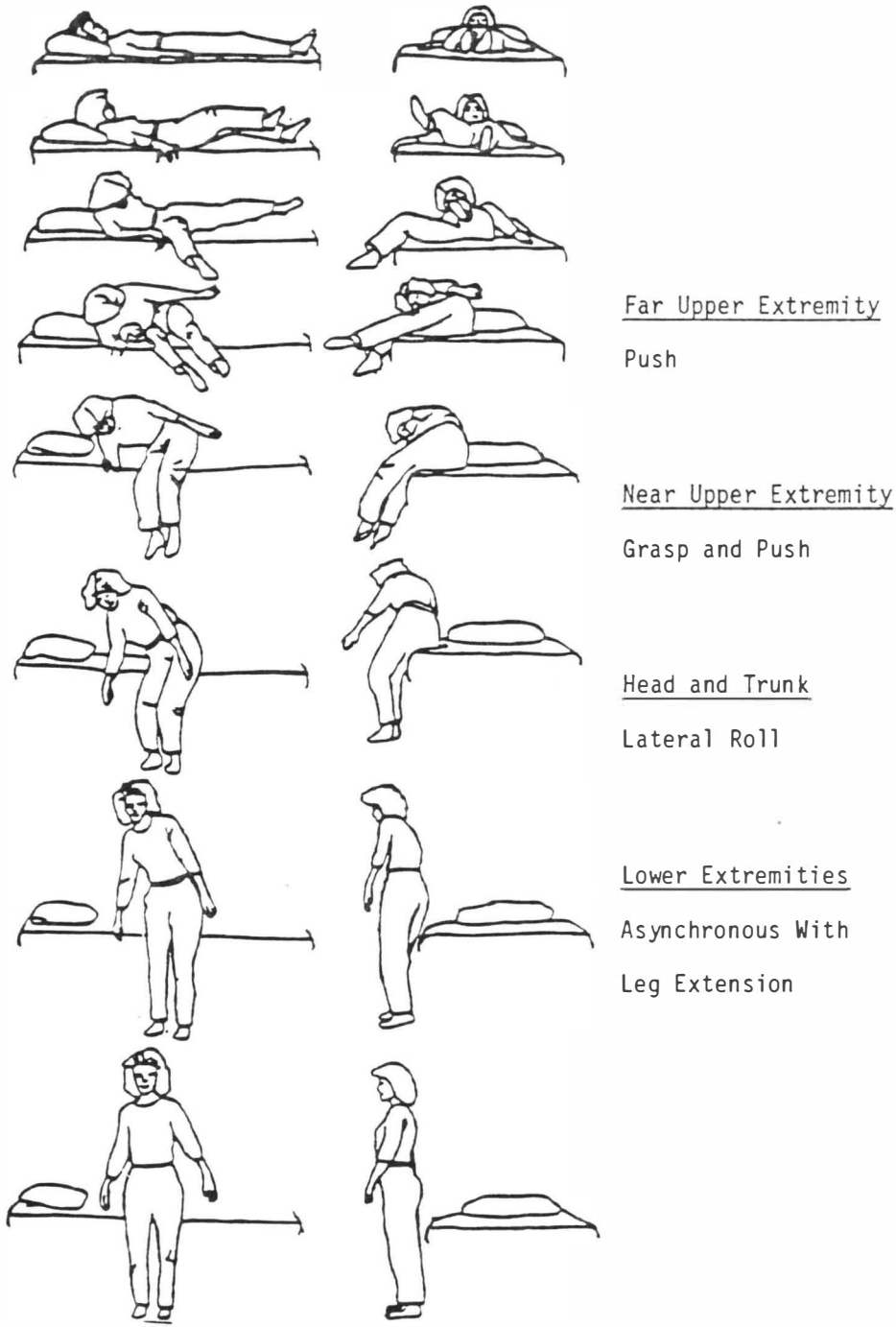



Figure 1. Movement Pattern Illustrations (a) (From Sarnacki, 1985).

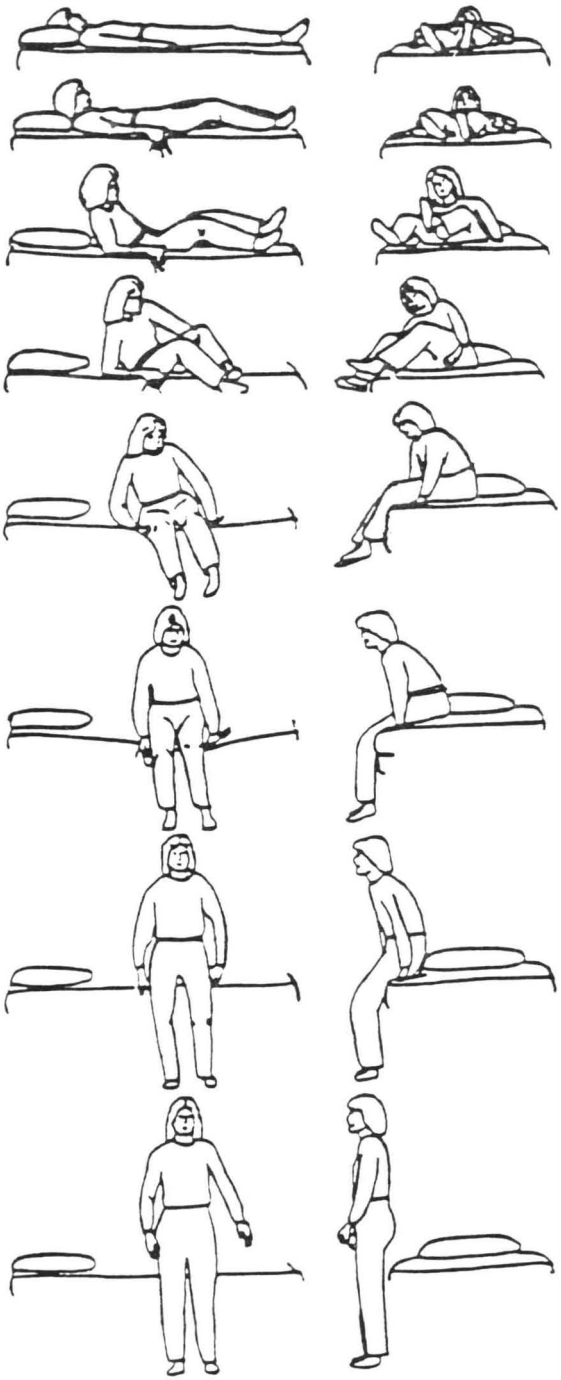
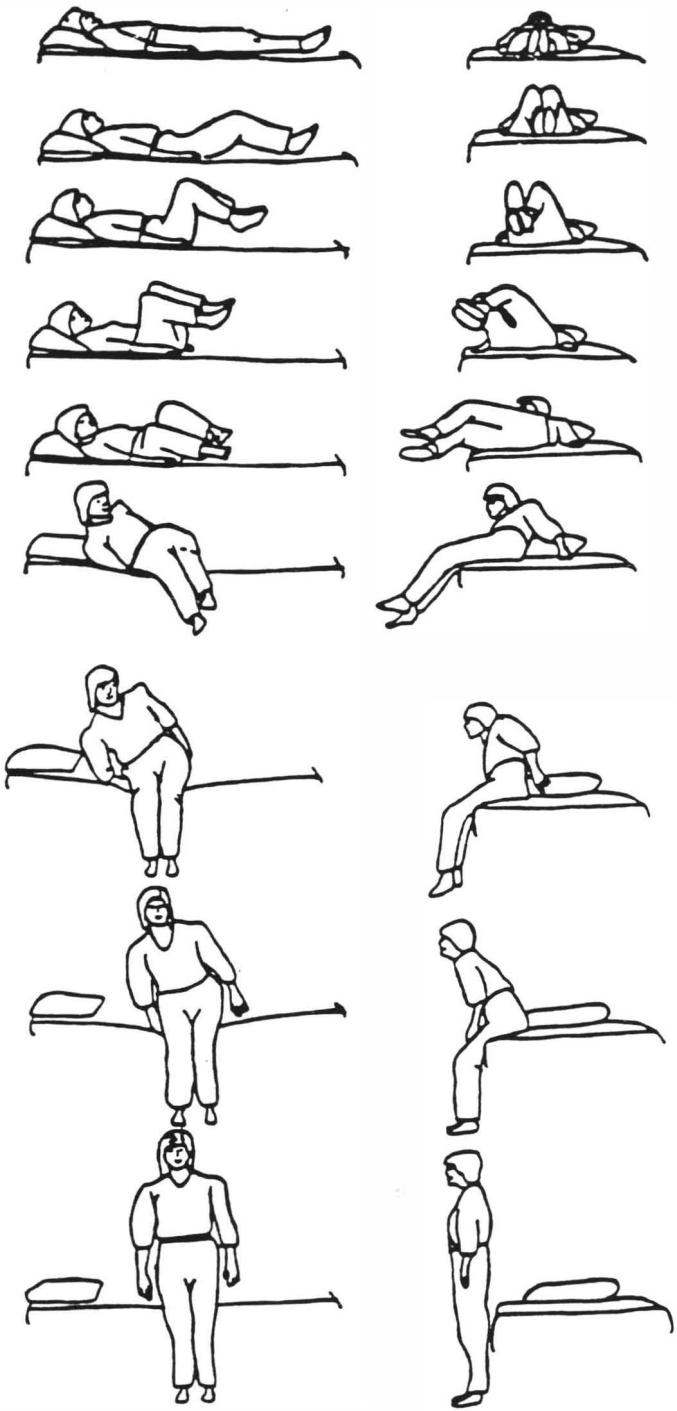



Figure 2. Movement Pattern Illustrations (b) (From Sarnacki, 1985).



Far Upper Extremity

Push

Near Upper Extremity

Push

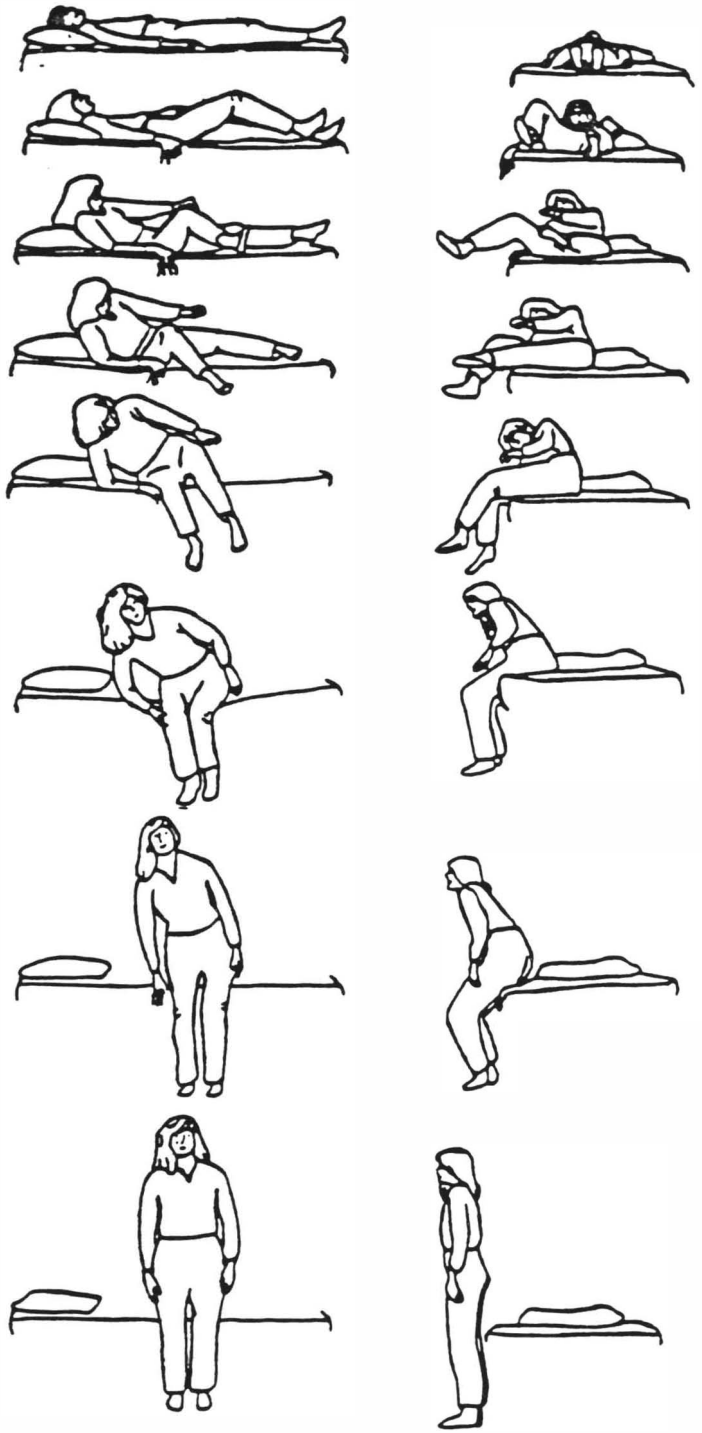
Head and Trunk

Pelvis Leading

Lower Extremities

Synchronous

Figure 3. Movement Pattern Illustrations (c) (From Sarnacki, 1985).



Far Upper Extremity

Lift or Lift and Reach

Near Upper Extremity

Grasp and Push

Head and Trunk

Roll-Off

Lower Extremities

Asynchronous With

Leg Extension

Figure 4. Movement Pattern Illustrations (d) (From Sarnacki, 1985).

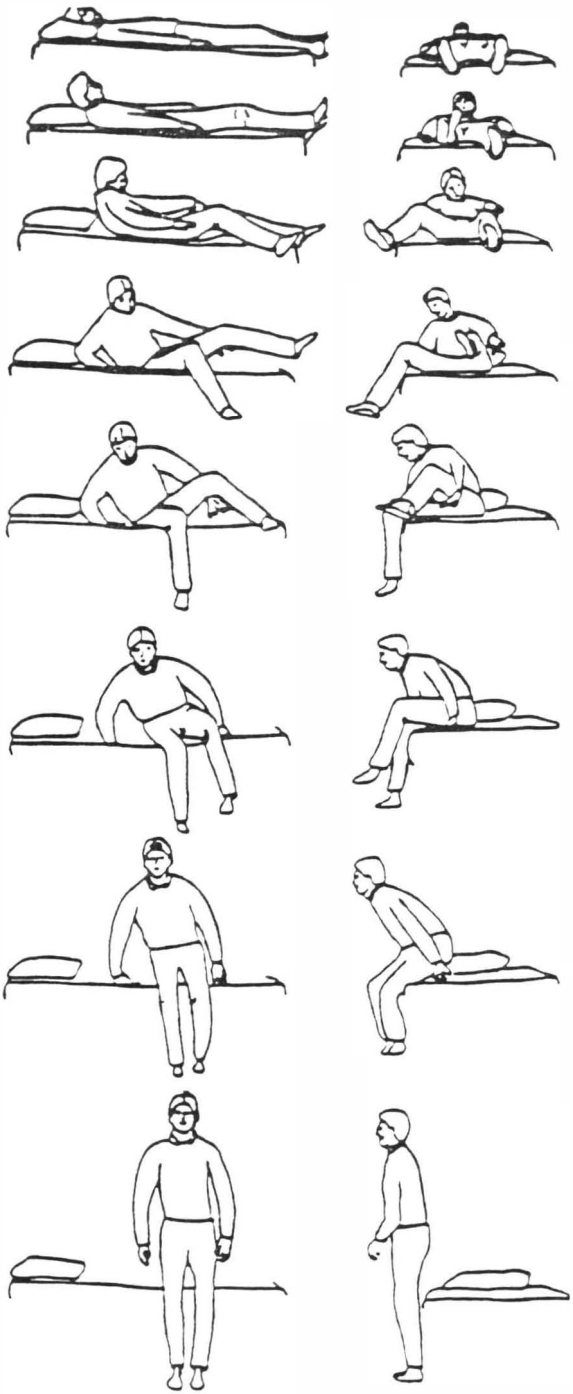



Figure 5. Movement Pattern Illustrations (e) (From Sarnacki, 1985).

individuals pass through the same developmental sequence. Intransitivity means that the order of steps within the sequence does not vary (Roberton, 1978). Any subject demonstrating more than one movement pattern during several performances of a task would be expected to vary only among adjacent movement patterns in a developmental sequence. A violation of this criterion could refute the universality of the sequence (Roberton, 1977).

Sarnacki rearranged the movement pattern categories until all individuals who demonstrated variability in the movements across 10 trials varied only among adjacent movement patterns. For example, suppose two possible developmental orders were movement patterns 1, 2, 3, and 4 successively or movement patterns 4, 3, 2, and 1 successively. Subjects who demonstrated movement pattern 2 may also have demonstrated patterns 1 and 3 and have been considered to vary among adjacent steps of both possible sequences. Subjects who demonstrated movement pattern 2 and also patterns 1 and 4 would have varied among non-adjacent steps of both sequences.

Once the movement pattern categories were ordered, Sarnacki had to decide if the correct developmental sequence was, for example, patterns 1, 2, 3, and 4 or patterns 4, 3, 2, and 1. Previous research (McGraw, 1945; Schaltenbrand, 1928; VanSant, 1983) was consulted to hypothesize the first movement pattern as pattern 1 or pattern 4. Since subjects in her study varied only among adjacent movement patterns in the proposed developmental sequences, Sarnacki hypothesized that the developmental sequences were ordered correctly.

The usefulness of studying a single age group of subjects to hypothesize developmental sequences prior to conducting a more time-consuming and costly longitudinal study has been demonstrated previously. Roberton (1977 & 1978) found that for subjects who varied only among adjacent movement patterns, the hypothesized developmental sequences of the movement patterns used to throw were supported in a later longitudinal study. For subjects who varied among non-adjacent movement patterns, the hypothesized developmental sequences were not supported longitudinally.

Across-trial variability was also examined in the present study to determine if all subjects varied only among adjacent movement patterns in the hypothesized developmental sequences. A longitudinal study would need to be conducted to ultimately validate these hypothesized sequences and to determine if all or most individuals progress through the sequences in the same order (VanSant, 1988).

## Adolescent Motor Development

The beginning of adolescence has been identified by physical indicators of puberty (Espenschade & Eckert, 1967). Throughout this study, however, adolescence refers to the second decade of life (Katchadourian, 1977).

Three topics pertaining to adolescent motor development are reviewed in this sub-section. Following a discussion of motor performance and movement pattern changes in sport activities, research on age-related differences among adolescents performing functional activities is presented.

Motor performance in sport activities. Motor performance refers to the product of movement, the final outcome, as opposed to the process or form used during the activity (Wickstrom, 1983). Most of the research that has been conducted on adolescent motor development has focused on motor performance. For example, researchers have examined age changes in how far subjects could jump or throw a ball, how fast they could run a given distance (Clarke, 1971; Espenschade, 1940) or how many push-ups they could do (Dimock, 1935). In each of these longitudinal studies, age changes have been found. Since age changes in motor performance are well documented throughout adolescence, one might expect to also find age changes in the movement patterns used to perform a given activity.

Movement pattern changes in sport activities. Movement pattern changes during adolescence in the development of the overarm throw have been examined in two studies (Halverson et al., 1982; Roberton & Langendorfer, 1979). The purpose of Roberton and Langendorfer's (1979) study was to determine if proposed developmental sequences for the overarm throw were validated in a group of subjects followed longitudinally. Seven subjects, four females and three males, were filmed performing a forceful overarm throw between the ages of three and seventeen years. Developmental changes in the movement patterns used to throw were still occurring during adolescence. In general, males achieved more advanced movement patterns, approximately five years sooner than the females. Female subjects had still not reached the highest level of throwing for the humerus or forearm by 17 years of age.

Halverson et al. (1982) also found support for developmental change in the movement patterns used to throw during adolescence. One purpose of their study was to assess changes in subjects' throwing movements

between kindergarten and seventh grade. Fifty-four children were filmed during early childhood. As seventh graders, thirty-nine of those children were refilmed throwing a tennis ball as hard as possible.

By seventh grade, large percentages of subjects had still not reached advanced levels of throwing for each of three body regions. Again, advanced movement patterns generally appeared in females five to six years later than in males. Halverson et al. (1982) proposed that these sex differences may have been present because most male subjects reportedly performed this activity more frequently than female subjects.

Because sex differences have been found in the movement patterns used to throw, an attempt was made in the present study to have an equal number of males and females in each age group of subjects. Possible sex differences in the movement patterns used to get out of bed were therefore controlled.

Movement pattern changes continuing during adolescence have also been described for hopping. The hopping performance of one male subject was reported at 37 months, at 13 years (Halverson et al., 1973), and at 16 years (Roberton & Halverson, 1984).

There were significant changes in the boy's hopping performance between three and 13 years. By 13 years, he was easily projecting his body forward in space when compared to his performance at three years. By 16 years, however, the boy's arms were still not both moving synchronously with his legs. Synchronous movements of the arms and legs are considered indicative of advanced hopping ability (Roberton & Halverson, 1984). Although the conclusions that can be made based on one subject are limited, this subject demonstrated that, as with

throwing, the movement patterns used to hop were still developing during the adolescent years.

Age-related differences in the movement patterns used by teen-agers for functional activities. Whether developmental changes occur in the movement patterns used by adolescents for functional activities has not been determined. Age-related differences have been found in this age group, however, in the movement patterns used to roll from supine to prone (Boucher, 1988). The first purpose of Boucher's cross-sectional study was to determine if movement pattern descriptions formed in a study of young adults (Richter, 1985) were accurate and comprehensive descriptors of adolescent rolling movement patterns. The second purpose was to determine if age-related differences in the movement patterns used to roll corresponded with developmental sequences proposed from the young adult study.

Twenty subjects 13 years of age, thirty subjects 15 years of age, and twenty subjects 17 years of age were videotaped during 10 consecutive trials of rolling from supine to prone (Boucher, 1988). Movement patterns were classified for the UE, HT, and LE body regions.

The movement pattern descriptions, formed in Richter's (1985) study of young adults, were found to be accurate and comprehensive descriptors of the movement patterns used by teen-agers to roll. Age-related differences were present in the movement patterns used to roll. Richter's (1985) proposed developmental sequences for the UEs and LEs were not supported because Boucher (1988) found that the movement pattern frequencies did not vary with age in a manner consistent with the hypothesized developmental order. Richter's HT sequence proposed for young adults did receive support in Boucher's study because the

observed movement pattern frequencies did vary with age in the hypothesized order.

Since age-related differences were found in the movement patterns used to roll, Boucher's research has important implications for the present study. Her study is the only work known to have demonstrated age-related differences in the movement patterns used by adolescents to perform a righting task. Whether age-related differences exist among adolescents in the movement patterns used to perform other functional activities, such as getting out of bed, needs to be examined.

## Cross-sectional Versus Longitudinal Developmental Research Designs

A single research design consideration is reviewed in this subsection. The benefits and limitations of cross-sectional versus longitudinal research are discussed.

In a longitudinal study, the same individuals are examined at different points in time. In a cross-sectional study, different age groups of individuals are examined at the same point in time (Drew & Hardman, 1985).

Cross-sectional studies have both benefits and limitations over longitudinal studies (Drew & Hardman, 1985). The major benefits are the decreased time and expenses involved because subjects from different age groups are tested at a single point in time. In longitudinal studies, the same individuals are followed for repeated assessments over a longer period of time. Because of the greater time involved, there are often problems with subjects dropping out of longitudinal studies and with long-term expenses.

There are three main limitations of cross-sectional studies. The major limitation occurs when the data is interpreted. The dissimilarity between individuals of different ages can only be used to hypothesize developmental sequences (Drew & Hardman, 1985). Hypothesized sequences require validation in a longitudinal study. Also, to ensure that the various sequence levels are observed, the age intervals of subjects must be carefully chosen (Roberton, Williams, & Langendorfer, 1980). Finally, if there is wide variation in the age of attainment of levels within the sequence, the sequence order may not be observed in a cross-sectional study, particularly if the age intervals are small (Roberton et al., 1980).

In the present study, 11, 14, and 17 year old adolescents were selected because age-related differences in the incidence of movement patterns used to roll were not great for 13, 15, and 17 year old teen-agers (Boucher, 1988). The most common rolling pattern was the same for the 15 and 17 year old teen-agers; the 13 year old teen-agers differed from the older teen-agers only in the LE movements. Age-related differences among teen-agers in the movement patterns used to roll may have been more apparent if a larger age range of subjects had been studied.

## Summary

This chapter contained a review of literature pertinent to the present study. Writings from three major areas were addressed: the functional activity of rising to standing from supine on a bed, adolescent motor development, and cross-sectional versus longitudinal developmental research designs.

When physical therapists evaluate and teach a functional activity, such as getting out of bed, knowing both if a patient can perform the activity and the movements used are important. However, the movement patterns used to get out of bed are not the focus of the functional assessment indices reviewed. In these indices, ordinal levels of measurement are used to indicate how much assistance a person requires to get out of bed or the extent to which a person is confined to bed.

Few descriptions of the movement patterns used to get out of bed were found in the rehabilitation literature. These descriptions are not based on research designed to identify movement patterns demonstrated by able-bodied individuals when getting out of bed.

The movement patterns demonstrated in each of four body regions when getting out of bed were recently described in a study of young adults. A developmental sequence of movement patterns for each body region was hypothesized. These sequences have not been validated, nor has the comprehensiveness of these movement pattern descriptions been determined for individuals in other age groups.

Although motor performance and movement pattern changes with age have been demonstrated during the adolescent years for sport activities, such changes have not been shown for the movement patterns used to perform functional activities, such as getting out of bed. Age-related differences have been found, however, in the movement patterns used by adolescents to roll from supine to prone.

Cross-sectional studies have both benefits and limitations compared to longitudinal studies. Although cross-sectional studies involve less subject attrition, time, and expense than longitudinal studies,

developmental sequences hypothesized in a cross-sectional study ultimately require validation in a longitudinal study.

In the present cross-sectional study, age-related differences in the movement patterns used by adolescents to get out of bed were examined. Developmental sequences, hypothesized from a study of young adults getting out of bed, were screened. Subject variability across trials was also examined to determine if all individuals who demonstrated variability in the movement patterns used to get out of bed varied only to adjacent steps in the proposed sequences.

# Chapter III

## Methods

### Subject Characteristics

Able-bodied 11, 14, or 17 year old adolescents were subjects in the present study. An attempt was made to have an equal number of males and females in each age group. Individuals were excluded from this study if, during verbal questioning, any orthopedic, neurologic, or cardiopulmonary condition was reported that could have interfered with their ability to come to standing from supine on a bed.

Subjects were recruited from public or private schools and a Church youth group in the greater Richmond, Virginia area. A school principal, teacher, or youth minister was contacted by telephone or letter (see Appendix A) explaining the purpose and nature of this study and asking permission to recruit students or youth group members as subjects. If a letter was mailed, a follow-up phone call was made 10 days after mailing. After the contact person agreed to allow the students or youth group members to participate, arrangements were made, at each principal's, teacher's, or minister's discretion, to schedule videotaping times and locations. Potential subjects were given, or parents/guardians of potential subjects were mailed, a parental/guardian

letter and consent form (see Appendix B). Parents/guardians were asked to sign and return the consent form to their son/daughter's teacher or youth minister or directly to this investigator. In addition to parental/guardian consent, all subjects were asked to read and sign a subject consent form (see Appendix C) at the time of data collection.

## Data Collection

Equipment. One RCA CMR300 Pro Wonder Video Camcorder and one National PK-956N Color Video Camera mounted on tripods were used to videotape subjects performing the task of getting out of bed. Each camera was equipped with an automatic focus, a power zoom lens, and an electronic view finder. The video camera was connected to an Avatar PS-20S Video Camera Power Supply and either a Sharp XA-110 Video Cassette Recorder (VCR) or Panasonic PV-1560 Omnivision VCR.

The same bed was used during each videotaping session. This standard twin size bed measured approximately 1.88 m long by .96 m wide by .51 m high. A caster was placed under each wheel of the bed frame to minimize movement of the bed. Sheets were used to cover the mattress. A covered, standard size pillow was placed at the head of the bed.

Layout of data collection site. Two cameras were used during videotaping to obtain complete views of subjects getting out of bed. A side view camera was positioned perpendicular to the length of the bed. A foot view camera was positioned perpendicular to the width of the bed. The cameras were positioned approximately 7.2 m and 6.2 m from the center of the bed for the side and foot view cameras respectively. The distance from the floor to the camera lens' center was approximately

.87 m for the side view camera and approximately .93 m for the foot viewcamera. A board with two sets of numbers was placed within view of both cameras to identify subject and trial numbers (see Figure 8).

The camera distances were similar to, but not identical to, those used by Sarnacki (1985). In her study, a single filming site was used. In the present study, six different videotaping sites were used. The camera distances were altered to accommodate the room size at the first data collection site and to still have subjects in the field of view as they rose from the bed. Originally, this investigator planned to have subjects rise toward the right side of the bed as in the young adult study (Sarnacki, 1985). However, because the taping site at the first school necessitated that subjects rise toward the left, all subjects were asked to rise toward the left side of the bed.

Procedures. This investigator and assistants collected the data. The purpose and procedures of the study were first explained to the subject. To ensure consistency in the instructions, a subject instruction checklist (see Appendix D) was completed for each participant. After any of the subject's questions regarding the study were answered, the subject was asked to read and sign a consent form (see Appendix C). If participants asked how they should get up, they were told to "Just get up as fast as you can."

Each subject was asked to remove shoes and socks and to lie supine in the center of the bed with the arms at the sides of the body. Before the first trial, the subject was asked to perform the task quickly in order to minimize time for thinking about the form of the movements used during the activity (VanSant, 1988). Participants were also told before their first trial that they could request a brief rest between trials.

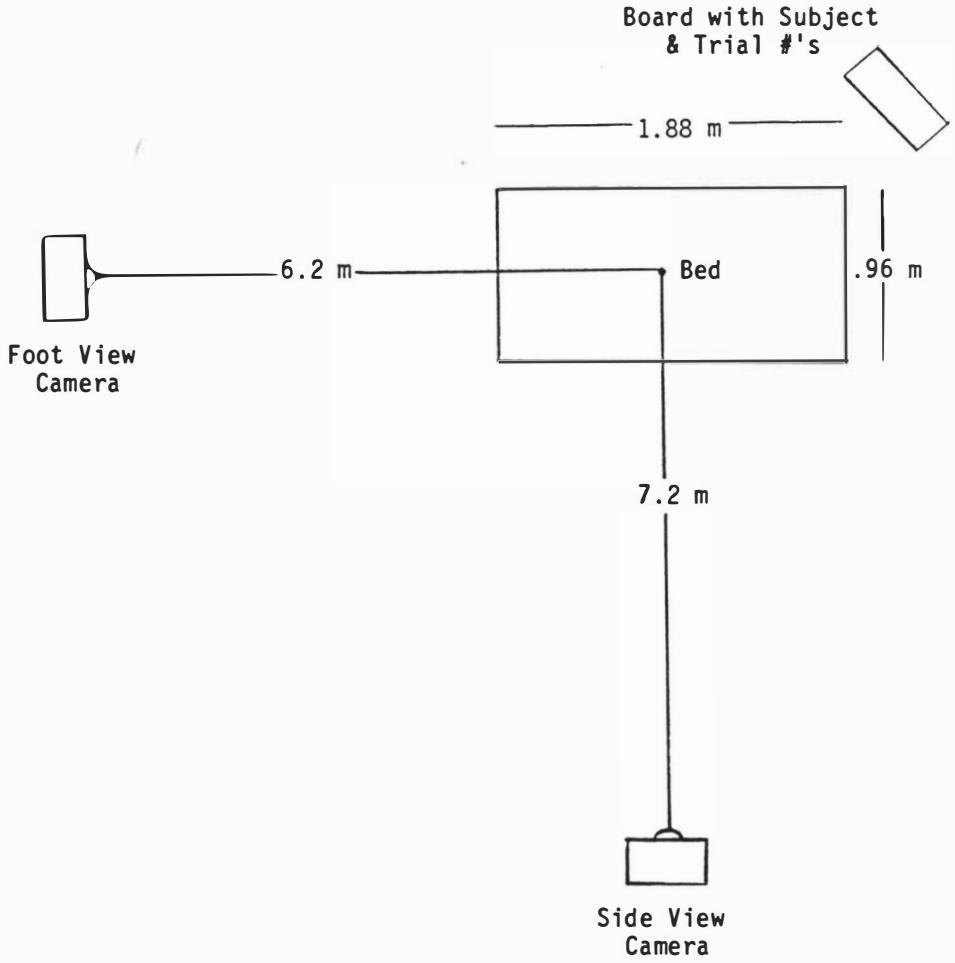



Figure 8. Overhead View of Videotaping Site (Not drawn to scale).

Two commands, "ready" and "go," were given by the investigator. On the command "ready," video-recording was started or was in process, and on the command "go," the subject rose from the bed toward the left side as rapidly as possible and remained standing until asked to lie back down. Ten consecutive trials were videotaped. Unless a rest was requested, the interval between trials was generally equivalent to the time required to turn to the next trial number and for the subject to return to the supine position on the bed.

No videotaped trials were lost during data collection. Some trials were revideotaped because of investigator error, a false start by the subject, or a misunderstanding by the subject of the task to be performed. A list of these errors and the corresponding trial numbers on the videotapes are contained in Appendix E.

## Data Reduction

Training for data reduction. To become competent classifying movement patterns using Sarnacki's (1985) categories, this investigator reviewed Sarnacki's films of young adults getting out of bed while studying the movement pattern descriptions for each of the four body regions (see Tables 1-4). Fifty trials from Sarnacki's films of young adults were then randomly selected by this investigator. The movement patterns of each body region observed on these trials were independently classified by the thesis director and this investigator.

This investigator's results were compared to those of the thesis director to determine percent exact agreement classifying movement patterns for each of the four body regions. Sarnakci (1985) and the thesis director achieved approximately 88% to 97% exact agreement

classifying movement patterns for each of the four body regions. In the present study, if less than 85% exact agreement was obtained, discrepancies were identified, and any misinterpretations of the movement pattern descriptions were corrected. Additional sets of 50 randomly selected trials were classified by both raters until at least 85% exact agreement was reached for each body region.

Movement pattern classification. Videotapes were reviewed and analyzed using a television monitor and VCR with stop action, slow motion playback capabilities. To categorize the movement patterns demonstrated by each subject when standing from supine on a bed, the movement pattern descriptions found in Tables 1-4 were used. The movement patterns of the LUE and the HT were classified from the side view videotapes. The movement patterns of the RUE and the LEs were classified from the foot view videotapes. When classification of a movement pattern could not be determined, the foot view videotapes were reviewed for the LUE and the HT, and the side view videotapes were reviewed for the RUE and the LEs.

Beginning with the LUE, the first trial of all subjects was classified, followed by the second trial of all subjects, etc. until all subjects' LUE movement patterns had been classified. This procedure was used to minimize investigator bias. As needed, decision rules were written to further distinguish movement pattern differences. The new decision rules and Sarnacki's (1985) decision rules that were used to assist with movement pattern classification appear in Appendix F. If movement patterns were observed that could not be classified using one of the existing descriptions, those movement patterns were described in writing. This data reduction procedure was repeated for each of the other three body regions.

Objectivity and reliability. After data reduction was completed, inter-rater objectivity classifying the adolescent movement patterns was examined for each body region. Data from 60 trials of the adolescent data were randomly selected by this investigator and classified by the thesis director. These results were compared to the original categorizations of the investigator. If less than 85% exact agreement was obtained, discrepancies were identified, and any misinterpretations of the movement pattern descriptions were clarified. If needed, additional or revised decision rules (see Appendix F) were written by the thesis director and this investigator to assist with movement pattern classification. This investigator then repeated the data reduction process for any body region with less than 85% exact agreement. Inter-rater objectivity was reexamined until at least 85% exact agreement was obtained for each region. Kappa statistics (Cohen, 1960) were calculated to estimate inter-rater reliability for each body region.

Intra-rater objectivity was also examined. This investigator reclassified the data from the same randomly selected 60 trials used to determine inter-rater objectivity. These results were compared to the original categorizations of the investigator, and percent exact agreement was determined for each body region.

## Data Analysis

Sub-question. In order to answer the main question of this study, the following sub-question was answered first: "Are descriptions of the movement patterns used by young adults when rising to standing from supine on a bed (Sarnacki, 1985) comprehensive descriptions of the

movement patterns used by adolescents performing the same task?" To answer this question, the movements demonstrated by subjects in the present study were analyzed to determine if all movements could be classified using the adult descriptions (see Tables 1-4). If all movement patterns could be classified, the patterns were comprehensive representations of the movements used by adolescents for that body region(s). If movement pattern descriptions needed to be added, the patterns were not comprehensive representations of the movements used by adolescents for that body region(s).

Main question. The main question was, "Are there age-related differences in the movement patterns exhibited by adolescents when rising to standing from supine on a bed that correspond to developmental sequences proposed from a previous study of young adults (Sarnacki, 1985)?" To answer this question, four steps were followed. For each body region, the percent occurrence of each movement pattern was computed across all trials within each age group. Percent occurrences of these patterns were presented in tables and graphed with respect to age to illustrate age-related movement pattern differences. The tables and graphs were examined to determine if younger subjects demonstrated, with a greater frequency than older subjects, movement patterns hypothesized to predominate earlier. Similarly, the tables and graphs were examined to determine if older subjects demonstrated, with a greater frequency than younger subjects, movement patterns hypothesized to predominate later.

Question two. The second question was, "What is the most common combination of RUE, LUE, HT, and LE movement patterns used by each age group of adolescents to rise to standing from supine on a bed?" To

answer this question, the movement pattern combinations observed across each of a subject's trials were first presented in tables for each age group. The percent occurrence of each observed movement pattern combination was then calculated and presented in tables for each age group across all trials. The most common movement pattern combination across all trials for each age group was lastly identified, illustrated, and compared across age groups.

Question three. The final question was, "Does individual variability in the movement patterns used to rise to standing from supine on a bed support the hypothesis that all individuals progress through the proposed developmental sequences in the same order?" Intra-subject variability was examined to answer this question. Once the number of subjects who varied movement patterns within a body region was determined, this intra-subject variability was examined to determine if any individuals varied to non-adjacent movement patterns in the hypothesized sequences. The number of subjects who varied among non-adjacent patterns and the movement patterns to which they varied were determined for each body region and presented in tables.

# Chapter IV

## Results

The findings of this study are presented in this chapter. After reviewing subject characteristics and the results of objectivity and reliability tests, the questions of this study are addressed. First the sub-question, "Are descriptions of the movement patterns used by young adults when rising to standing from supine on a bed comprehensive descriptions of the movement patterns used by adolescents performing the same task?" is answered. The main question is addressed next: "Are there age-related differences in the movement patterns exhibited by adolescents when rising to standing from supine on a bed that correspond to developmental sequences proposed from a previous study of young adults?" The next question, "What is the most common combination of RUE, LUE, HT, and LE movement patterns used to get out of bed by each age group?" is then answered. Finally, the question "Does individual variability in the movement patterns used when getting out of bed support the hypothesis that all individuals progress through the proposed developmental sequences in the same order?" is addressed.

### Subject Characteristics

The sample consisted of sixty-two adolescents: twenty, 11 years of age; twenty-one, 14 years of age; and twenty-one, 17 years of age. One

14 year old female was eliminated from data analysis because of a reported left wrist fracture four weeks prior to the videotaping session. One 17 year old male was also eliminated from data analysis because of a reported history of seizures.

Of the remaining sixty adolescents, there were 10 females and 10 males in the 11 year old group, 11 males and 9 females in the 14 year old group, and 9 males and 11 females in the 17 year old group. The mean age, age range, and standard deviation are reported for each group in Table 5.

## Inter-rater Objectivity Prior to Data Reduction

Greater than 85% exact agreement was achieved by the thesis director and this investigator classifying the movement patterns of each body region from 50 trials randomly selected from Sarnacki's (1985) films of young adults getting out of bed. The percentages of exact agreement between the classifications of the thesis director and this investigator for the FUE, NUE, HT, and LEs were 88%, 88%, 94%, and 90%, respectively.

## Objectivity and Reliability

Eighty-five percent or better exact agreement was achieved between the thesis director and this investigator on the first objectivity test for the FUE, NUE, and LEs using the videotapes of adolescents. The HT region required two separate objectivity tests. Inter-rater objectivity classifying the movement patterns from 60 randomly selected trials was 95%, 85%, 90%, and 86.5% exact agreement for the FUE, NUE, HT, and LEs,

Table 5

Sample Mean Age, Age Range, and Standard Deviation

| Age Group (Yrs) [a] | Mean Age | Age Range | Standard Deviation (Mos) [b] |
|---|---|---|---|
| 11 | 11 Yrs 3.2 Mos | 11 Yrs 0.5 Mos to 11 Yrs 9.6 Mos | 2.6 |
| 14 | 14 Yrs 5.8 Mos | 14 Yrs 0.5 Mos to 14 Yrs 11.0 Mos | 3.4 |
| 17 | 17 Yrs 6.4 Mos | 17 Yrs 1.3 Mos to 17 Yrs 11.9 Mos | 3.0 |

Note. $n$ = 20 for each age group.

[a] Yrs = Years. [b] Mos = Months.

respectively. To estimate the extent of agreement not due to chance, Kappa statistics (Cohen, 1960) were calculated. The values of Kappa for the FUE, NUE, HT, and LEs were 0.91, 0.76, 0.89, and 0.82, respectively.

This investigator's intra-rater objectivity was also determined. The percentages of exact agreement between the first and second categorizations by this investigator were 98% for both the FUE and the NUE, 93.3% for the HT, and 85% for the LEs.

## Movement Pattern Comprehensiveness

In this section, the question regarding the comprehensiveness for adolescents of Sarnacki's (1985) descriptions of the movement patterns used by young adults to get out of bed is addressed. Beginning with the FUE, this question is answered separately for each body region.

Far upper extremity. No new movement patterns were described for the FUE. All movement patterns were classified (see Appendix G) using the categories presented in Table 1 and the decision rules outlined in Appendix F.

Several subjects who varied from Sarnacki's (1985) descriptions of FUE action were observed. One subject was noted to push first on the ipsilateral side of her body as she moved toward sitting. She then reached across in front of her trunk to push the second time on the opposite side of her body before rising to standing. Four subjects, in a total of 10 trials, were observed to push on their thighs instead of the bed before rising to standing. New decision rules (see Appendix F, Numbers 2, 3a, and 3b for the FUE) were written to assist in the objective classification of these movement patterns.

Near upper extremity. One new movement pattern category was formed for the NUE. Two subjects, in one trial each, were observed to lift the NUE off the bed and reach forward, never pushing or grasping on the bed. This pattern was similar to Sarnacki's Lift or Lift and Reach pattern for the FUE (see Table 1). This new pattern is illustrated in Figure 9. The categorical description of this movement pattern appears in Table 9.

To more objectively categorize the adolescent NUE movement patterns, four additional decision rules (see Appendix F, Numbers 1b, 1c, 2, and 3b for the NUE) were generated. Two decision rules were written to categorize the movement patterns of subjects who lifted the NUE before pushing but did not appear to move the NUE toward the head of the bed. A third decision rule was written to categorize the movement patterns of subjects who grabbed their leg, not the bed, as they pushed toward sitting. The fourth decision rule was written to categorize the movement patterns of subjects who had their wrist instead of their hand as the last part of the NUE to leave the bed.

Head and trunk. No new movement patterns were described for the HT region. However, a large proportion of subjects demonstrating the Lateral Roll pattern appeared to roll completely toward sidelying using less trunk flexion (see Figure 10) than was apparent on the films of Sarnacki's young adults whom she classified as Lateral Roll. Even though the thesis director and this investigator met the 85% objectivity criterion on the second objectivity test, three of the four HT categories were rewritten (see Table 10) to better describe the movement patterns and to make them more generalizable.

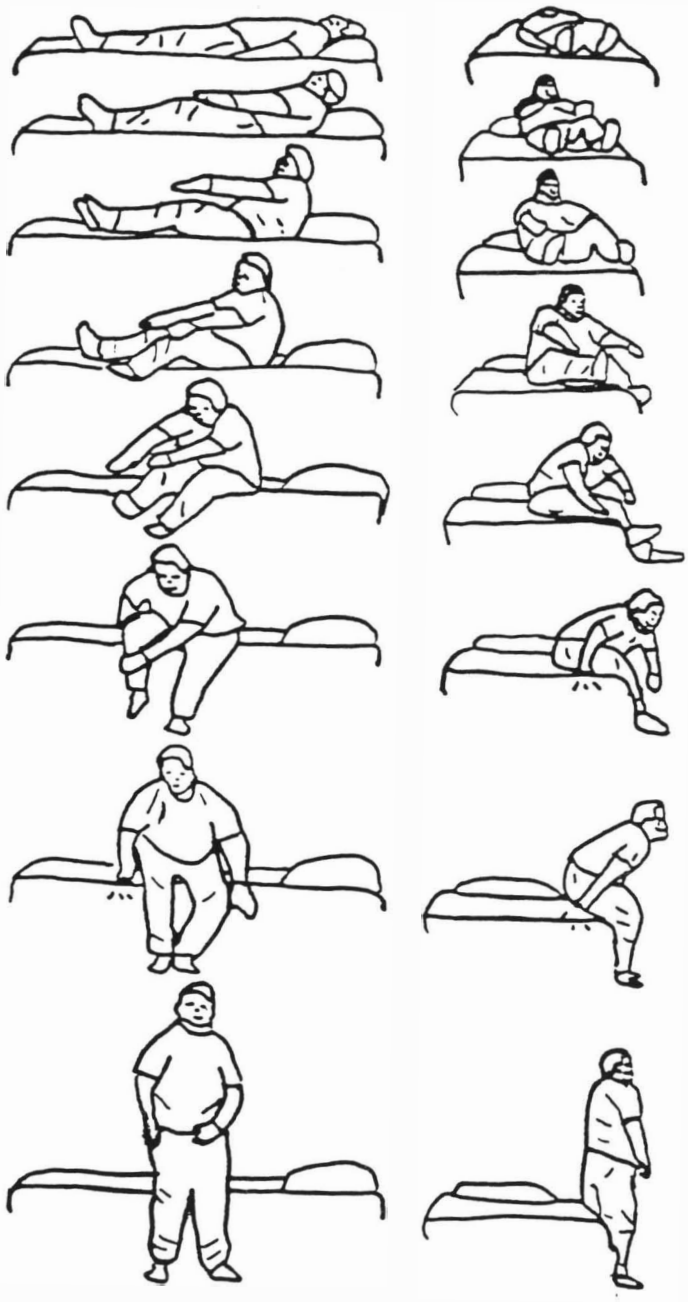


Figure 9. Illustration of the Near Upper Extremity Lift and Reach Movement Pattern (Subject 38, Trial 6).

Table 9

Near Upper Extremity Movement Pattern Categories, Including the Lift and Reach Pattern Observed in This Study

1) Lateral Lift and Push: The upper extremity lifts or slides on the supporting surface toward the head of the bed. The entire upper extremity, or some part of it, is placed on the bed and pushes until the extremity is in the extended or nearly extended position, and the hand is the only part of the extremity remaining on the bed. The hand lifts, and the extremity may be used as a balance assist (From Sarnacki, 1985).

2) Grasp and Push: The upper extremity slides or lifts to position the hand to grasp the edge of the bed. The entire upper extremity, or some part of it, pushes down on the bed while the hand grips on the edge. The upper extremity lifts and may be used as a balance assist (From Sarnacki, 1985).

3) Push: The entire upper extremity, or some part of it, pushes into the bed. The extremity lifts from the bed and may be used as a balance assist (From Sarnacki, 1985).

4) Lift and Reach: The upper extremity is lifted off the bed without pushing. The extremity may be used to reach forward and/or as a balance assist.

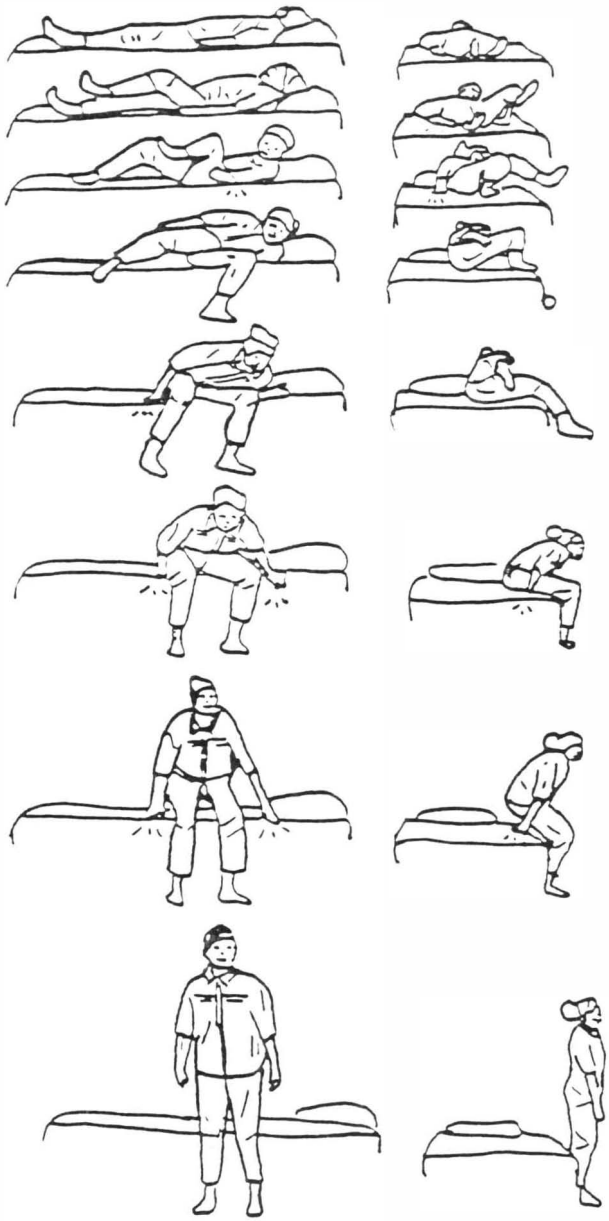


Figure 10. Subject Illustrating a Lateral Roll Pattern in the Head and Trunk Region. Note the Minimal Amount of Trunk Flexion Used to Move Toward Side-facing. This Girl was Typical of Adolescents Demonstrating the Lateral Roll Pattern (Subject 39, Trial 3).

Table 10

Revised Head and Trunk Movement Pattern Categories

| |
|---|
| 1) Pelvis Leading: The lower trunk rotates to the side. At sidelying, the upper side of the pelvis drops to the bed, and the trunk lifts and turns toward side facing. The subject may be in a symmetrical sitting posture before standing (From Sarnacki, 1985). |
| 2) Lateral Roll: The head and trunk turn toward the side facing position with minimal flexion toward the foot of the bed. In the side-facing position, one buttock is off the bed, and the shoulders and pelvis are aligned and displaced toward the head of the bed. When the buttocks come off the bed, the head and trunk may be displaced toward the head of the bed, or the subject may be in a symmetrical sitting posture.[a] |
| 3) Roll-Off: The head and trunk flex and turn toward side facing with the weight shifted to one buttock.[b] Just before both buttocks come off the bed, the head and trunk are displaced toward the head of the bed through lateral flexion and/or rotation. |
| 4) Come to Sit: The head and trunk flex symmetrically or flex and turn toward side facing by pivoting on one or both buttocks.[c] Just before both buttocks come off the bed, the trunk is in a symmetrical sitting posture, though it may be flexed forward. |

[a]The words underlined indicate changes made in Sarnacki's (1985) original description of the Lateral Roll pattern. [b]The Roll-Off pattern was revised by eliminating the following sentence: "In the side-facing position, the pelvis may drop to a level position." [c]The Come to Sit pattern was revised by eliminating the following sentence: "If the trunk pivots on one buttock, the pelvis may drop to a level position before standing."

In addition to the movement pattern revisions, five decision rules (see Appendix F for the HT) were generated or modified. Two decision rules (see Appendix F, Numbers 1a and 1b for the HT) were generated to distinguish the Lateral Roll pattern from the Roll-Off and Come to Sit patterns. In the latter two patterns, the subjects turned toward side-facing with more flexion of the trunk than was seen in subjects who demonstrated a Lateral Roll pattern. Sarnacki (1985) had distinguished the Lateral Roll and Roll-Off patterns based upon when the tip of the shoulder furthest from the side-view camera first appeared. In the decision rules generated as a result of this study, the categories were distinguished by observing if there was a space between the NUE and the trunk when the subject first reached side-facing. The remaining three decisions rules (see Appendix F, Numbers 2a-c for the HT) were modifications of Sarnacki's (1985) decision rules to distinguish the Roll-Off and Come to Sit movement patterns.

The data from this study were reclassified for the HT region after the categorical descriptions and decision rules were revised. Intra-rater and inter-rater objectivity tests were repeated using 100 randomly selected trials from this study's data, Sarnacki's (1985) data, and a data set generated by Ford-Smith (in progress). These three data sets were used to assess the generalizability of the revised HT categories and decision rules. To determine this investigator's intra-rater objectivity using the revised descriptions and decision rules, this investigator recategorized the 100 trials one week later.

The percentage of exact agreement between the classifications of the thesis director and this investigator was 88%. The value of Kappa, calculated to estimate inter-rater reliability, was 0.76. Intra-rater objectivity was 97%.

Lower extremities. No new movement patterns were identified for the LEs, and no new decision rules (see Appendix F) were written. The thesis director observed two variations, which may represent new movement patterns. One involved the use of excessive flexion of the LE on the side toward which the subject was rising as this LE was lifted off the bed. This investigator reviewed Sarnacki's films and felt that this movement was not a new pattern because the movement could be categorized into existing categories and was similar to the movements demonstrated by subject 13, trial two and subject 27, trials six and nine in Sarnacki's study. An example of this exaggerated flexion movement is illustrated in Figure 11.

The second variation involved the use of excessive internal rotation of the far lower extremity, the LE opposite the side toward which the subject was rising, as this LE moved across the bed. This internal rotation at the hip was often combined with flexion at the knee. Because this movement could be classified into the pre-existing categories, based on the relative position of the LEs throughout the movement from supine to standing, a new movement pattern description was not developed by this investigator. An example of this movement is illustrated in Figure 12.

Summary. No new movement patterns were identified in the FUE, HT, and LE body regions. Three of the four HT movement pattern descriptions were revised, however, to better describe the adolescents' movement patterns. For the NUE region, one new movement pattern was identified. A categorical description was generated for this NUE movement pattern which was named Lift and Reach.

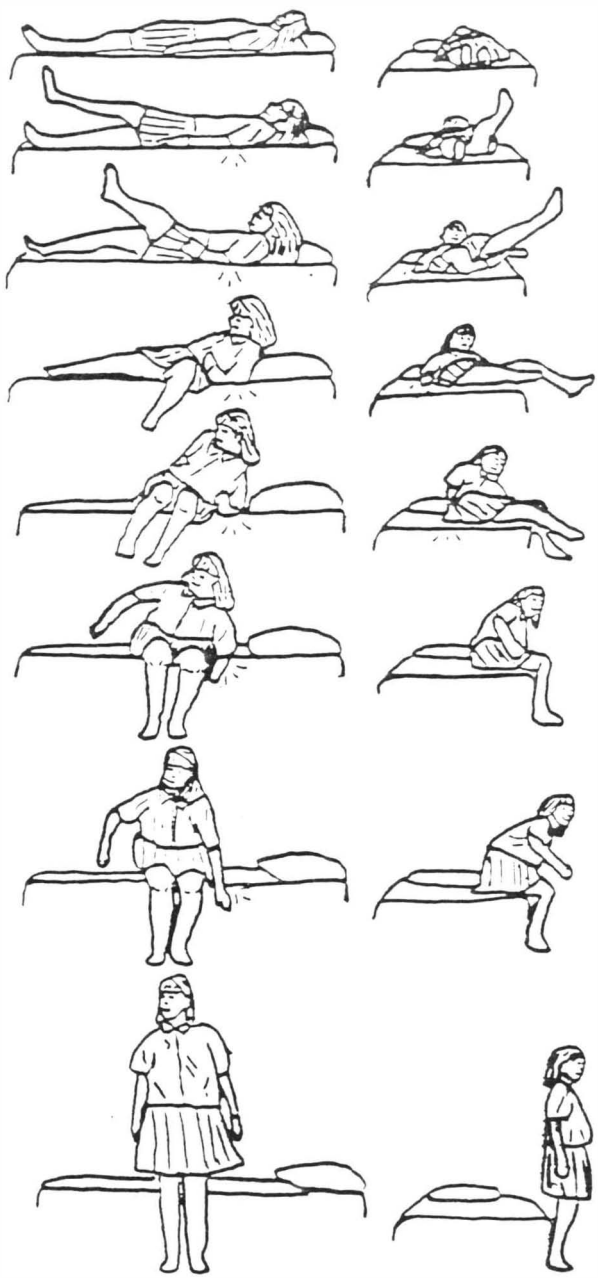


Figure 11. Illustration of Exaggerated Flexion Movement of the Leading Lower Extremity (The movement was categorized as 2-Asynchronous With Leg Extension. Tracing from Subject 48, Trial 8).

Figure 12. Illustration of Excessive Internal Rotation of the Right Lower Extremity. (The movement was categorized as 2-Asynchronous With Leg Extension. Tracing from Subject 36, Trial 2.)

## Age-related Movement Pattern Differences and Hypothesized Developmental Sequences

The main purpose of this study was to determine if there are age-related differences in the movement patterns exhibited by adolescents when rising from a bed which correspond to developmental sequences proposed by Sarnacki (1985) from her study of young adults. Beginning with the FUE, the presence of age-related movement pattern differences is discussed separately for each body region. How these age-related movement pattern differences correspond to Sarnacki's hypothesized sequences is discussed in Chapter V.

Far upper extremity. The movement pattern developmental order hypothesized by Sarnacki (1985) for the FUE was Lateral Lift and Push, followed by Push, Double Push, Lift and Push, and finally Lift or Lift and Reach. The observed frequency of occurrence of each movement pattern is presented in Table 11 and graphed in Figure 13.

Lateral Lift and Push was the least frequently observed movement pattern in all three age groups. This pattern occurred at a very low frequency in 11-year-olds and was not observed in 14- or 17-year-olds.

Push was the second most common movement pattern in all three age groups. This movement pattern occurred with equal frequency in 11- and 14-year-olds and was seen at its highest frequency in 17-year-olds.

The most common movement pattern in all three age groups was Double Push. This pattern occurred at a high frequency in all three age groups. The frequency was greater in 14-year-olds than in 11-year-olds and was seen with a sharply reduced frequency in 17-year-olds.

Lift and Push was the third most common pattern in all three age groups. The frequency of occurrence of this movement pattern was

Table 11

Far Upper Extremity Movement Pattern Percent Occurrence (%)

| Movement Pattern Category[a] | Age Group (Years) | | |
|---|---|---|---|
| | 11 | 14 | 17 |
| | % | % | % |
| 1-Lateral Lift and Push | 1.5 | 0 | 0 |
| 2-Push | 16.5 | 16.5 | 20.0 |
| 3-Double Push | 72.0 | 83.0 | 63.5 |
| 4-Lift and Push | 8.0 | 0.5 | 13.0 |
| 5-Lift or Lift and Reach | 2.0 | 0.0 | 3.5 |
| Total: | 100.0 | 100.0 | 100.0 |

Note. n = 200 trials for each age group.

[a] The categories are listed in the developmental order hypothesized by Sarnacki (1985).

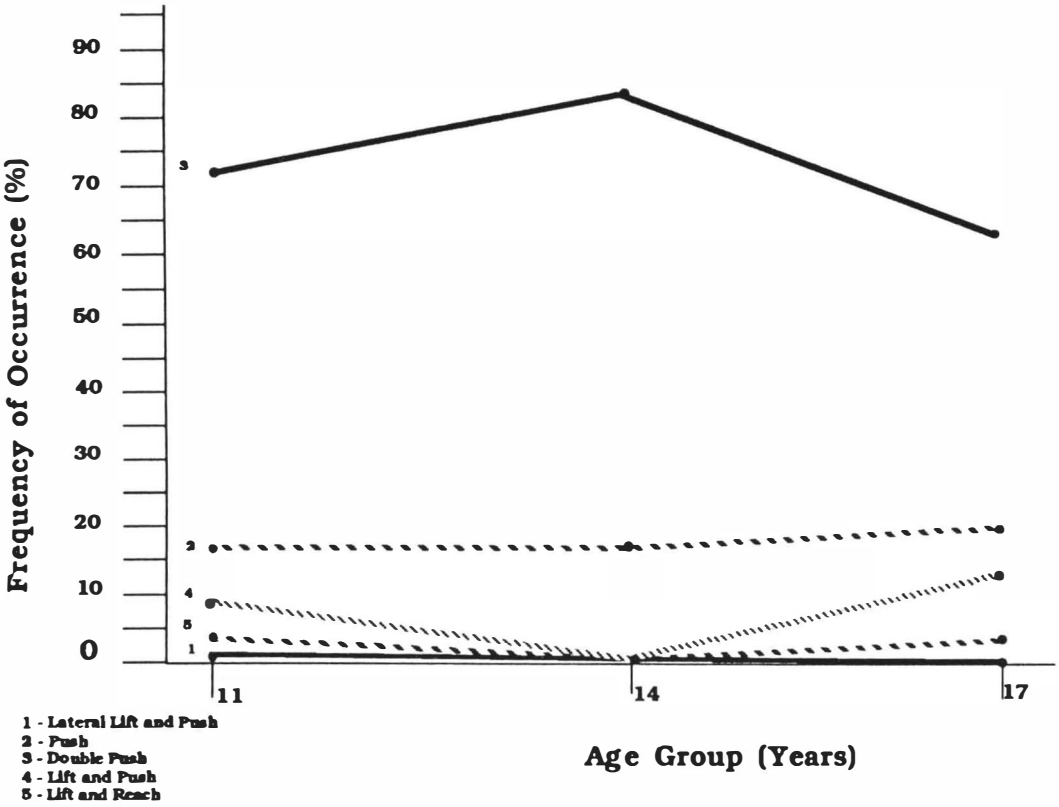



**Figure 13.** **Observed Frequency of Occurrence of Far (Right) Upper Extremity Movement Patterns.**

greater in 11- than 14-year-olds. The frequency was less in 14- than 17-year-olds.

Lift or Lift and Reach occurred at a very small frequency in 11- and 17-year-olds. This pattern was not observed among the 14-year-olds in this study.

Near upper extremity. Table 12 and Figure 14 report and illustrate the observed frequency of NUE movement patterns for each age group. Sarnacki (1985) hypothesized that the NUE movement patterns would become predominant in the following order: Lateral Lift and Push, Grasp and Push, and Push.

The frequency of occurrence of Lateral Lift and Push was higher in 11-year-olds than in 14- and 17-year-olds. The frequency was approximately the same in 14- and 17-year-olds.

Grasp and Push was less common in 11-year-olds than in 14- and 17-year-olds. Grasp and Push was the most common movement pattern in 14-year-olds and was the second most common movement pattern among 11- and 17-year-olds.

The Push pattern occurred at a higher frequency with each successively older age group. In 11- and 17-year-olds, Push was the most common movement pattern, slightly more common than Grasp and Push. In 14-year-olds, Push was the second most common movement pattern.

Lift and Reach occurred at a very small frequency in 11- and 17-year-olds. This movement pattern was not observed in 14-year-olds.

Head and trunk. Table 13 lists and Figure 15 illustrates the percent occurrence of each HT movement pattern for each age group. Sarnacki (1985) hypothesized that Pelvis Leading would be the first HT pattern to predominate, followed by Lateral Roll, Roll-Off, and Come to Sit, in successive order.

Table 12

Near Upper Extremity Movement Pattern Percent Occurrence (%)

| Movement Pattern Category [a] | Age Group (Years) | | |
|---|---|---|---|
| | 11 | 14 | 17 |
| | % | % | % |
| 1-Lateral Lift and Push | 25.0 | 9.5 | 10.5 |
| 2-Grasp and Push | 36.5 | 48.5 | 42.0 |
| 3-Push | 38.0 | 42.0 | 47.0 |
| 4-Lift and Reach | 0.5 | 0 | 0.5 |
| Total: | 100.0 | 100.0 | 100.0 |

Note. n = 200 trials for each age group.

[a] Categories 1-3 are listed in the developmental order hypothesized by Sarnacki (1985).

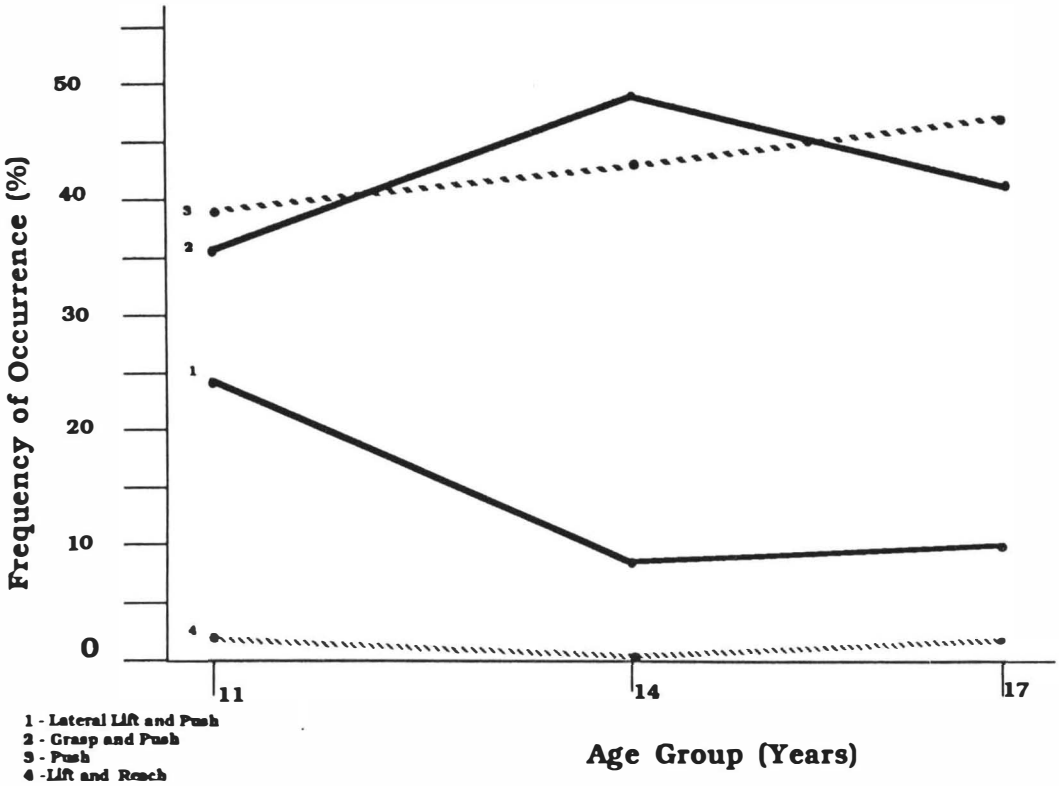



**Figure 14.** **Observed Frequency of Occurrence of Near (Left) Upper Extremity Movement Patterns.**

Table 13

Head and Trunk Movement Pattern Percent Occurrence (%)

| Movement Pattern Category[a] | Age Group (Years) | | |
|---|---|---|---|
| | 11 | 14 | 17 |
| | % | % | % |
| 1-Pelvis Leading | 5.0 | 0 | 4.5 |
| 2-Lateral Roll | 34.5 | 10.0 | 1.5 |
| 3-Roll-Off | 17.5 | 14.5 | 24.0 |
| 4-Come to Sit | 43.0 | 75.5 | 70.0 |
| Total: | 100.0 | 100.0 | 100.0 |

Note. n = 200 trials for each age group.

[a] The categories are listed in the developmental order hypothesized by Sarnacki (1985).

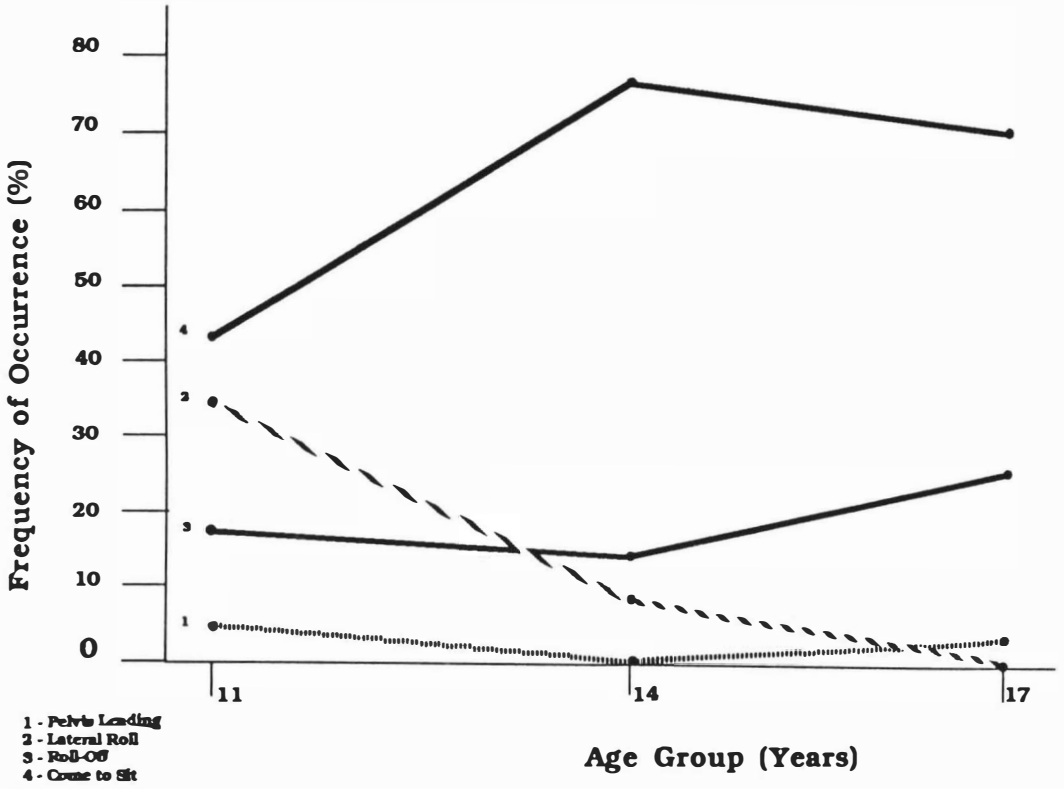



**Figure 15.** **Observed Frequency of Occurrence of Head - Trunk (HT) Movement Patterns.**

Pelvis Leading was observed at a very low frequency in 11- and 17-year olds. This pattern was not observed in 14-year-olds.

Lateral Roll was observed in more than one third of the trials of subjects 11 years of age. This pattern was seen in only 10% of the trials of subjects 14 years of age and at a very low frequency in the oldest subjects.

Roll-Off occurred at a similar frequency in 11- and 14-year-olds and then increased almost 10% between 14- and 17-year-olds.

Come to Sit was the most common pattern for all three age groups. The pattern demonstrated peak frequency in 14-year-olds. Among 11-year-olds, Come to Sit was approximately 30% less common than among 14-year-olds. This pattern was slightly less common in 17-year-olds than in 14-year-olds.

Lower extremities. The observed frequency of each LE movement pattern for each age group is listed in Table 14 and illustrated in Figure 16. Sarnacki (1985) hypothesized that the movement patterns would become predominant in the following order: Step-Off, Asynchronous With Leg Extension, Asynchronous, and Synchronous.

Step-Off, which was the least common movement pattern observed in 11-year-olds, was the most common movement pattern demonstrated by 14-year-olds. This pattern was significantly less common in 17-year-olds than in 14-year-olds.

The Asynchronous With Leg Extension pattern was the most common movement pattern demonstrated by 11- and 17-year-olds. This pattern was less common in the 14-year-olds who predominantly demonstrated a Step-Off pattern.

Table 14

Lower Extremity Movement Pattern Percent Occurrence (%)

| Movement Pattern Category[a] | Age Group (Years) | | |
|---|---|---|---|
| | 11 | 14 | 17 |
| | % | % | % |
| 1-Step-Off | 10.5 | 32.5 | 17.0 |
| 2-Asynchronous With Leg Extension | 44.5 | 28.0 | 47.5 |
| 3-Asynchronous | 32.5 | 26.0 | 28.5 |
| 4-Synchronous | 12.5 | 13.5 | 7.0 |
| Total: | 100.0 | 100.0 | 100.0 |

Note. n = 200 trials for each age group.

[a]The categories are listed in the developmental order hypothesized by Sarnacki (1985).

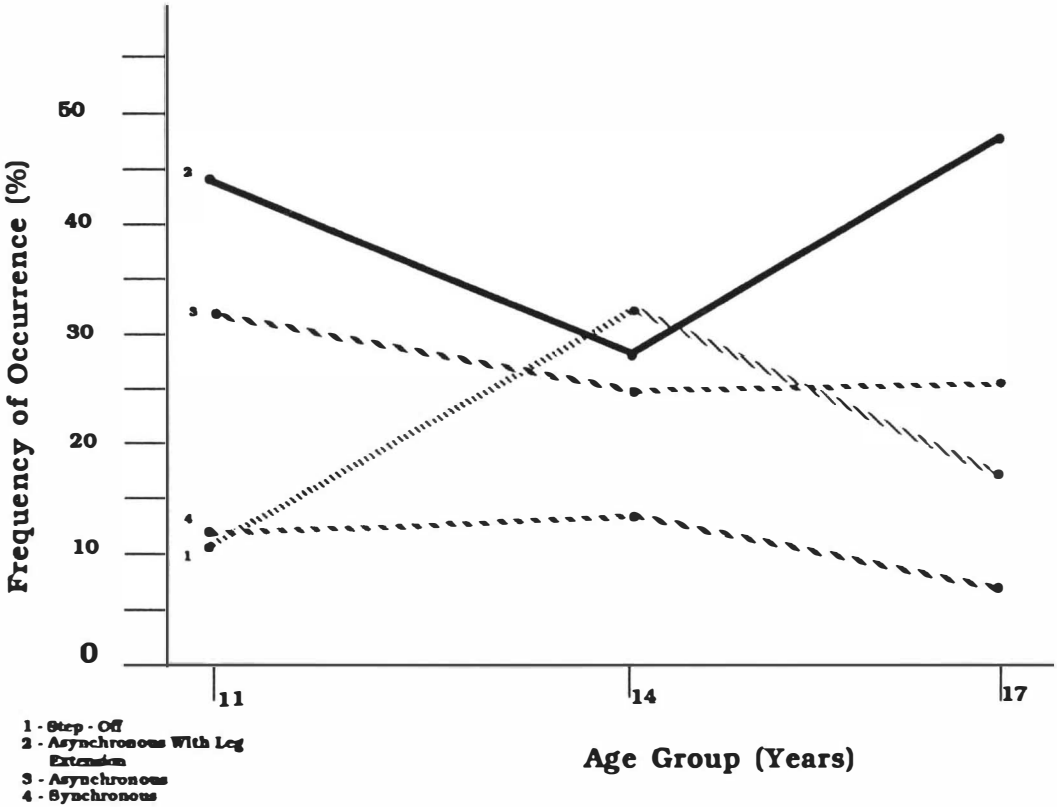



**Figure 16.** **Observed Frequency of Occurrence of Lower Extremity Movement Patterns.**

The Asynchronous pattern differed little in frequency across age groups. This pattern was observed in approximately 25% to 30% of the trials of each age group.

Synchronous, the movement pattern hypothesized by Sarnacki (1985) to become predominant last, also differed little in frequency among the adolescent age groups. This pattern varied between approximately 5% and 15% of the trials of the three groups.

Summary. The frequencies of each movement pattern observed in the three age groups were presented for the four body regions. Age-related differences were observed in the movement patterns of each body region.

## Most Common Movement Pattern Combination

The most common combination of RUE, LUE, HT, and LE movement patterns used by each age group to get out of bed is presented in this section. To determine the most common movement pattern combination, the percent occurrence of each combination was calculated.

A total of 89 different movement pattern combinations were observed across the three age groups. Sixty-seven different movement pattern combinations were observed in 11-year-olds, compared to 40 in 14-year-olds and 44 in 17-year-olds. No subject demonstrated the same movement pattern combination across all 10 trials. The percent occurrence of each observed movement pattern combination is presented in Appendix H, Tables 15, 16, and 17 respectively for subjects 11, 14, and 17 years of age.

The low incidence of the most common movement pattern combinations reflect the large amount of variability observed. The three most common movement pattern combinations (see Table 18) observed in each age group

Table 18

The Three Most Common Movement Pattern Combinations Across Trials for Subjects 11, 14, and 17 Years of Age (n = 200 Trials for Each Age Group)

| Age (Years) | Movement Pattern Combination F-N-T-L | Percent Occurrence (%) |
|---|---|---|
| 11 | 3-2-4-2 | 6.5 |
| | 3-3-2-2 | 5.5 |
| | 3-2-2-2 | 5.5 |
| | Total: | 17.5 |
| 14 | 3-2-4-1 | 12.5 |
| | 3-2-4-2 | 11.5 |
| | 3-2-4-3 | 9.0 |
| | Total: | 33.0 |
| 17 | 3-2-4-2 | 14.5 |
| | 3-3-4-2 | 9.0 |
| | 3-2-4-1 | 6.0 |
| | Total: | 29.5 |

Note. F = Far Upper Extremity.
N = Near Upper Extremity.
T = Head and Trunk.
L = Lower Extremities.

Far Upper Extremity Movement Patterns: 1-Lateral Lift and Push; 2-Push; 3-Double Push; 4-Lift and Push; 5-Lift or Lift and Reach.

Near Upper Extremity Movement Patterns: 1-Lateral Lift and Push; 2-Grasp and Push; 3-Push; 4-Lift and Reach.

Head and Trunk Movement Patterns: 1-Pelvis Leading; 2-Lateral Roll; 3-Roll-Off; 4-Come to Sit.

Lower Extremity Movement Patterns: 1-Step-Off; 2-Asynchronous With Leg Extension; 3-Asynchronous; 4-Synchronous.

accounted for approximately one third of the trials of the 14- and 17-year-olds but only approximately one fifth of the trials of the 11-year-olds.

For subjects 11 years of age, there were three common movement pattern combinations (see Figures 17, 18, and 19). These combinations occurred with almost equal frequency and differed from each other only in NUE or HT action. For all three movement pattern combinations, subjects pushed twice with the FUE, first as the subject moved toward sitting and again as the subject moved toward standing. In addition, the far LE was extended out in front of the near LE as the LEs moved over the edge of the bed. In one pattern (see Figure 17), the NUE grasped the edge of the bed as the head and trunk flexed toward sitting with minimal trunk rotation. In the second pattern (see Figure 18), the NUE pushed on the bed, without grasping, as the subject turned toward side-facing with minimal trunk flexion. In the third pattern (see Figure 19), the NUE grasped the edge of the bed as, again, the subject turned toward side-facing with minimal trunk flexion.

For subjects 14 years of age, there were two common movement pattern combinations (see Figures 20 and 17) which occurred with almost equal frequency. These two combinations differed from each other only in LE action. Both combinations consisted of two pushes with the FUE, one as the subject moved toward sitting and again as the buttocks were lifted off the bed. The hand of the NUE grasped the edge of the bed as the head and trunk flexed and turned toward sitting with minimal trunk rotation. In one pattern (see Figure 20), the far thigh was above the near thigh as the subject moved toward sitting.

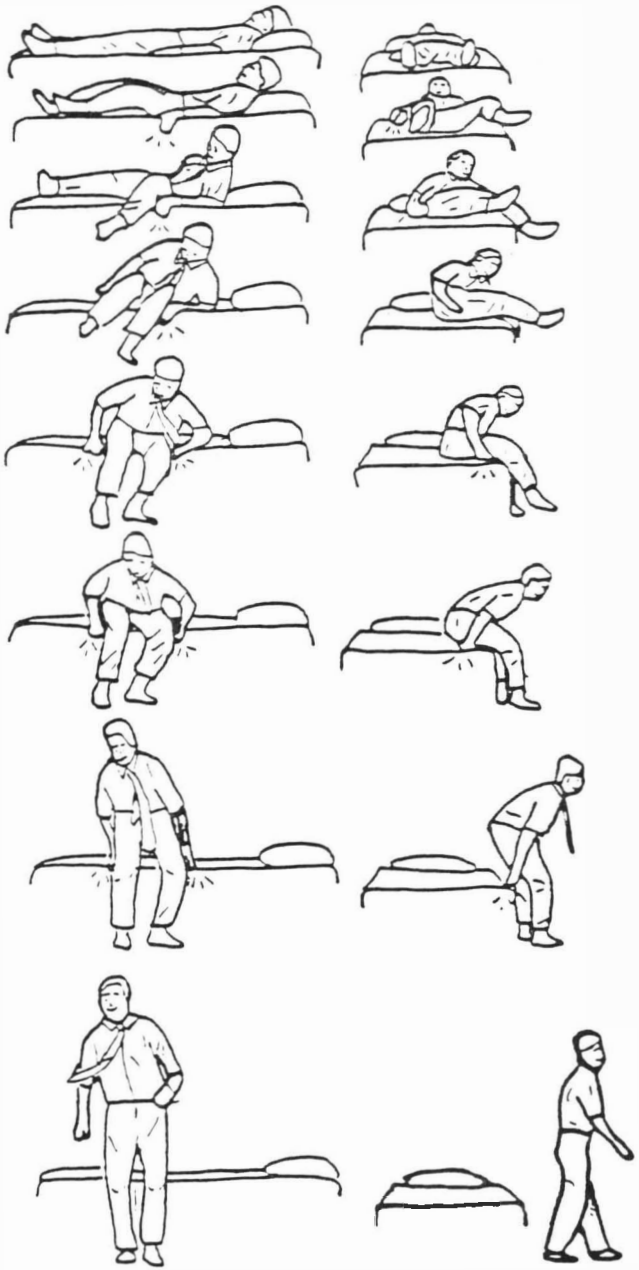



Figure 17. One of the Three Most Common Movement Pattern Combinations (MCMPC) Demonstrated by Subjects 11 Years of Age, One of the Two MCMPC Demonstrated by Subjects 14 Years of Age, and the MCMPC Demonstrated by Subjects 17 Years of Age (Subject 23, Trial 1).

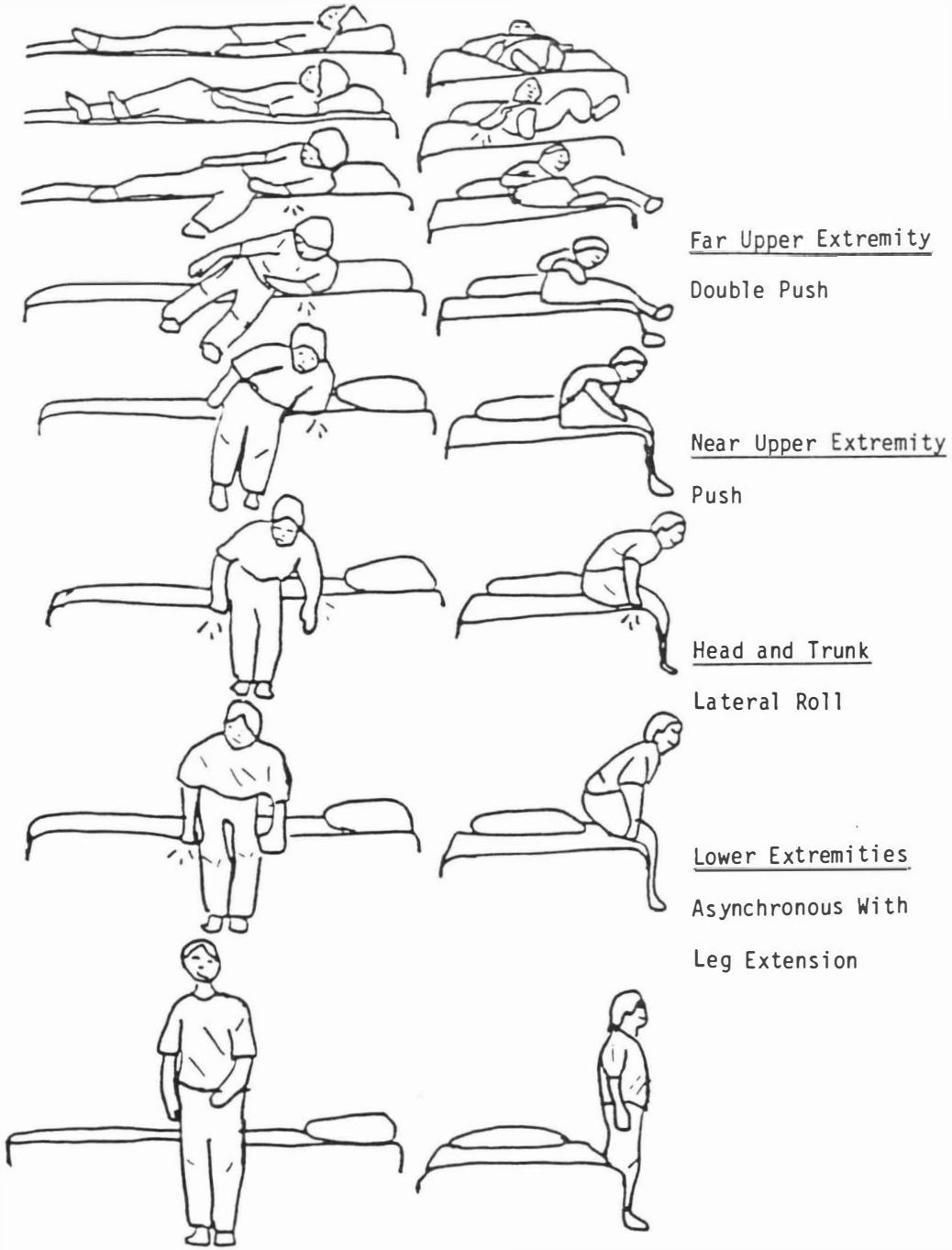



Figure 18. One of the Three Most Common Movement Pattern Combinations Demonstrated by Subjects 11 Years of Age (a) (Subject 21, Trial 2).

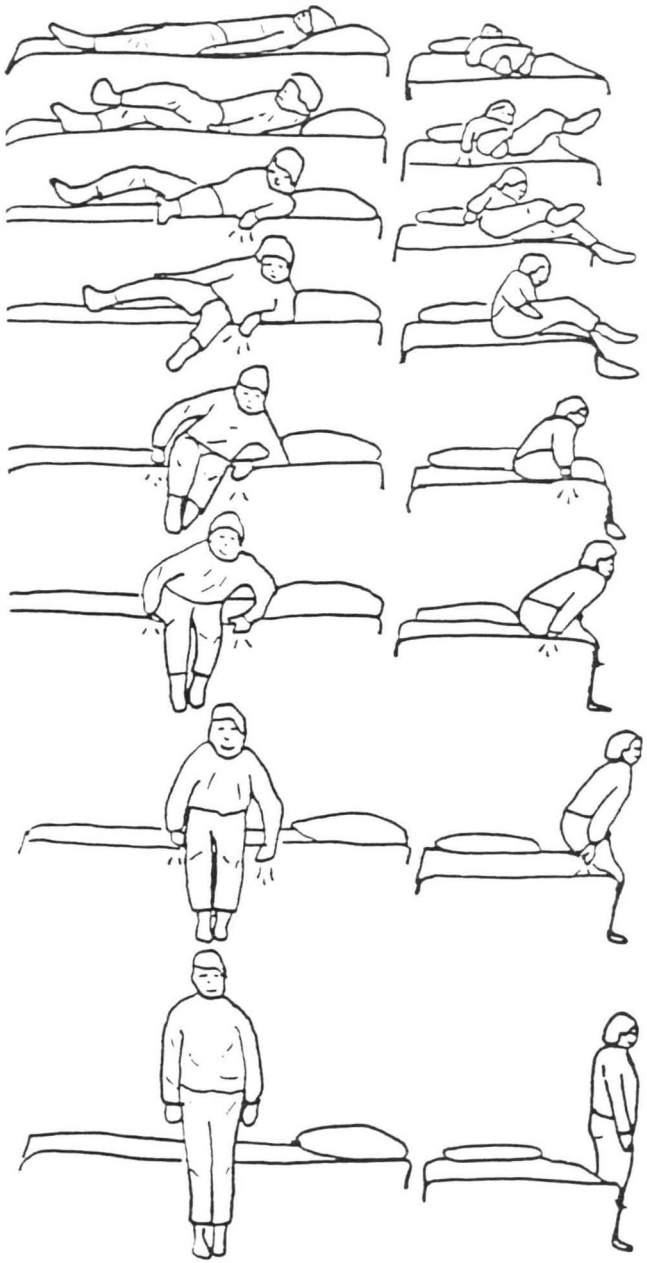



Figure 19. One of the Three Most Common Movement Pattern Combinations Demonstrated by Subjects 11 Years of Age (b) (Subject 31, Trial 4).

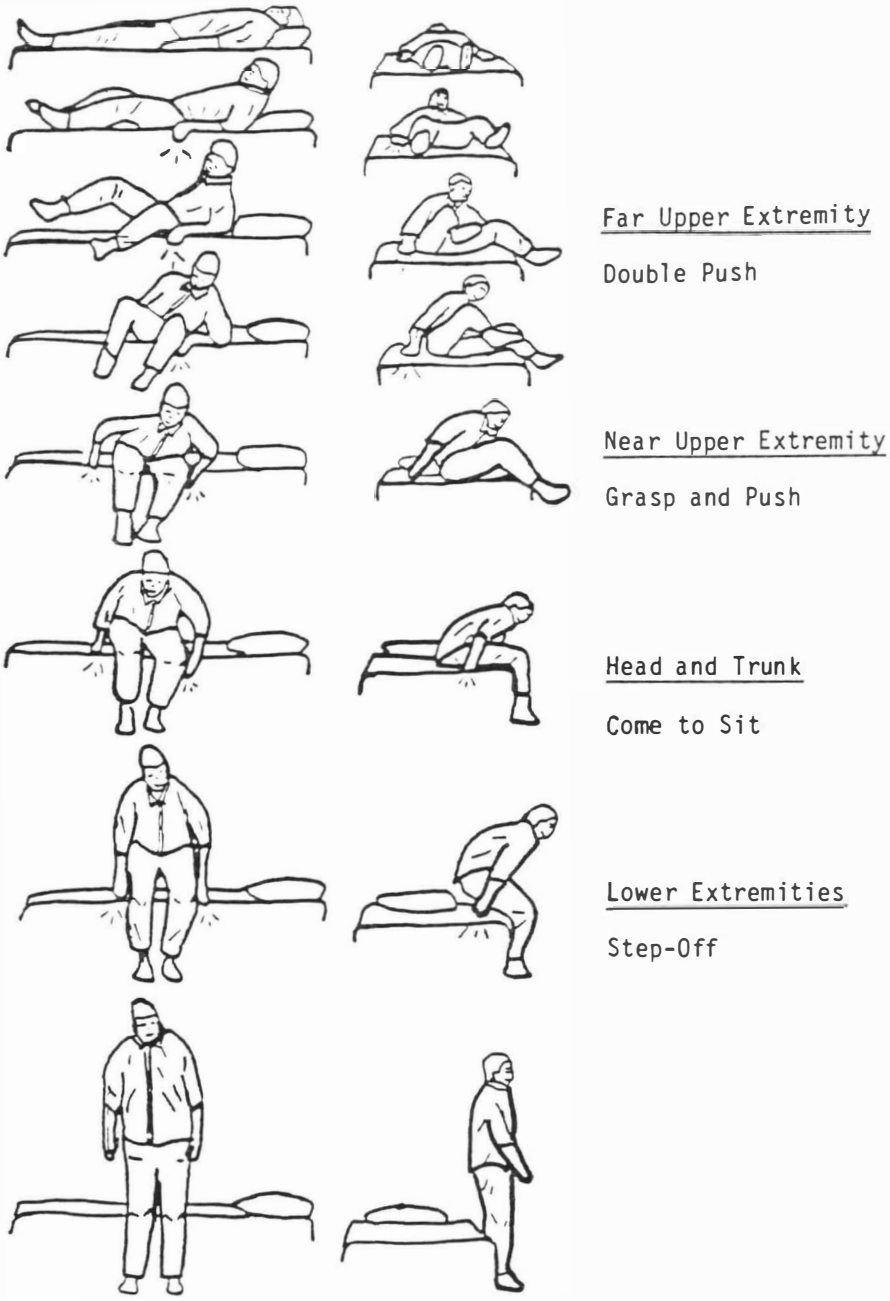



Figure 20. One of the Two Most Common Movement Pattern Combinations Demonstrated by Subjects 14 Years of Age (Subject 22, Trial 9).

In the second pattern (see Figure 17), the far LE was extended out in front of the near LE as the LEs moved over the edge of the bed.

For subjects 17 years of age, there was a single most common movement pattern combination (see Figure 17). This combination, which was also one of the most common combinations for the 11- and 14-year-olds, consisted of two pushes with the FUE, first as the subject moved toward sitting and again as the subject moved toward standing. The NUE grasped the edge of the bed as the head and trunk flexed and turned toward sitting with minimal trunk rotation. The far LE was extended out in front of the near LE as the LEs moved over the edge of the bed.

Summary. There were three common movement pattern combinations seen in 11-year-olds. Among 14-year-olds, there were two common movement pattern combinations. Among 17-year-olds, there was a single most common movement pattern combination. This combination was the same as one of the most common combinations seen among 11- and 14-year-olds. The low incidence of these most common combinations reflects the large amount of variability observed.

## Universality and Intransitivity of Hypothesized Developmental Sequences

Determining if individual variability in the movement patterns used when getting out of bed supported the hypothesis that all individuals progress through the proposed developmental sequences in the same order was the final purpose of this study. To determine this, intra-subject variability was examined.

Intra-subject movement pattern variability was great. For the FUE, NUE, HT, and LE body regions respectively, 30, 40, 41, and 54

subjects demonstrated more than one movement pattern during their ten trials. The subjects who demonstrated movement pattern variability and the movement patterns to which they varied are presented for each body region in Appendix I, Tables 19 through 22.

For each body region, subjects varied to non-adjacent steps in Sarnacki's (1985) hypothesized developmental sequences. Two, nine, six, and five subjects violated the adjacency criterion in the FUE, NUE, HT, and LEs respectively. No ordering could be found in which subjects varied only between adjacent patterns.

## Summary

The results of this study indicated that no new movement pattern categories were formed to describe FUE, HT, or LE action. One new movement pattern was observed in the NUE, and an additional movement pattern category was formed. Three of the four HT categories were revised to better describe the adolescents' movement patterns.

Age-related differences in the movement patterns used by 11, 14, and 17 year old adolescents to get out of bed were present for each of the four body regions. There were three common movement pattern combinations for subjects 11 years of age, two for subjects 14 years of age, and one for subjects 17 years of age. The most common movement pattern combination among 17-year-olds was one of the common combinations demonstrated by 11- and 14-year-olds. The low incidence of the most common movement pattern combinations was reflective of the large amount of variability observed. Finally, for each body region, there were subjects who varied to non-adjacent steps in Sarnacki's (1985) hypothesized developmental sequences.

# Chapter V

## Discussion and Conclusions

At the beginning of this chapter, the results of this research are discussed. Conclusions of this study are presented next. Implications of this research and recommendations for future studies follow. A summary of the study concludes the chapter.

### Movement Pattern Comprehensiveness

With the exception of one new movement pattern observed in the NUE, the movement patterns identified in Sarnacki's (1985) study of young adults did describe the movement patterns demonstrated by adolescents. Movement patterns observed in one age group of subjects getting out of bed, therefore, appear representative of most movement patterns observed in other age groups. Although developmentally earlier or later predominating movement patterns may not be observed when a sample of young adults is used to identify the movement patterns for a task (VanSant, 1988), Sarnacki's (1985) study of young adults getting out of bed proved a useful first step prior to studying adolescents.

Although no new movement patterns were observed in the HT region, the HT movement pattern descriptions required revision (see Table 10).

Additional decision rules (see Appendix F) also needed to be generated. There are two explanations of why this may have been so.

First, to distinguish between the Lateral Roll pattern where "The head and trunk turn toward the side facing position with minimal flexion..." and the Roll-Off pattern where "The head and trunk flex and turn toward side facing...," Sarnacki (1985) wrote the following decision rule: "If the tip of the left shoulder (the FUE) is seen within 0.63 m, classify the movement as Lateral Roll." This distance represented a fixed point in the background of the photographic field and was measured with a stick positioned behind the subject parallel to the length of the bed during data collection (S. J. Sarnacki, personal communication, August, 1988). This distance may vary depending on a subject's size or the initial position of the subject in relation to the head of the bed. Also, using a reference pole to categorize movement patterns would be impractical in clinical settings.

Second, Sarnacki's Lateral Roll pattern was observed in only four of her subjects during 17 trials. The low incidence of this movement pattern may have made it difficult to develop decision rules to fully distinguish between the Lateral Roll and the Roll-Off or Come to Sit movement patterns.

In general, adolescents were noted to roll toward sidelying with less trunk flexion than most of the young adults (Sarnacki, 1985). When this investigator reviewed Sarnacki's films using the decision rules outlined in Appendix F, only one of the 17 trials originally categorized as Lateral Roll remained categorized as Lateral Roll. Once the differences between the three movement patterns were more clearly

defined, Sarnacki's (1985) original movement pattern descriptions were revised (see Table 10).

Additional decision rules (see Appendix F) were also written for the FUE and NUE movement patterns to more objectively distinguish the patterns. These new decision rules may have been needed because of minor movement pattern variations observed among subjects in the present study. No new decision rules were needed to classify action using the LE movement pattern descriptions. Further study would be needed, however, to determine if the LE variations seen in this sample of adolescents represent variations of the movement patterns identified in the young adult study (Sarnacki, 1985) or possibly new movement patterns which may be observed with greater frequencies in other age groups.

The objectivity criterion of 85% exact agreement was achieved on the first objectivity test for the FUE, NUE, and LE regions and on the second objectivity test for the HT region. This indicates that the categorical descriptions and decision rules are objective and can be taught to other individuals.

## Age-related Movement Pattern Differences and Hypothesized Developmental Sequences

Age-related differences in the movement pattern frequencies were observed within each body region. These age-related differences between the three groups of adolescents were not always great enough to determine if the movement patterns were becoming more or less common with respect to age in a manner consistent with Sarnacki's (1985) hypotheses.

There are several explanations why the observed age-related differences may not have been greater. First, the three year age range

chosen may have been too small for the sequence to be manifested (Roberton et al., 1980). A larger age range of subjects could be used in future studies.

Second, the sample size may have been too small for specific trends to have been demonstrated. Because there were only twenty subjects in each age group, the movement patterns demonstrated by just one or two individuals could have significantly altered the observed frequencies of the various movement patterns. Future studies should include a larger sample size.

Third, the movement patterns identified may not represent developmental steps (Roberton et al., 1980). Additional cross-sectional studies involving subjects from older and younger age groups could help to further clarify whether or not age-related movement pattern differences exist which warrant longitudinal study.

Far upper extremity. As noted in Chapter IV, there was little difference between the three age groups in the frequency of occurrence of four of the five FUE movement patterns. The marked drop in the frequency of occurrence of the Double Push pattern between 14- and 17-year-olds was the most notable age-related difference. Because the age-related differences were limited, determining if the movement patterns were becoming more or less common in the order predicted by Sarnacki (1985) was not possible. This investigator, therefore, compared her adolescent data to the data obtained by Sarnacki in her study of young adults.

Sarnacki (1985) hypothesized that the movement patterns would become predominant in the following order: Lateral Lift and Push, Push,

Double Push, Lift and Push, and Lift or Lift and Reach. The low incidence of the Lateral Lift and Push pattern among adolescents as compared to young adults suggests that this pattern may be a later predominating movement pattern. This would not support Sarnacki's hypothesis that Lateral Lift and Push was the earliest pattern to predominate.

Push, the most common FUE movement pattern among young adults, occurred much less frequently among adolescents. The Double Push pattern which was predominant in adolescents was observed in less than 15% of the trials of young adults. In contrast to Sarnacki's prediction, the Double Push pattern likely becomes predominant before the Push pattern.

Lift and Push was observed in fewer of the trials of 14-year-olds and young adults than the 11- and 17-year-olds, always occurring less than 15%. Because of this low, variable incidence, predicting whether Lift and Push is an earlier or later predominating pattern could not be determined based upon age-related differences. Further cross-sectional study of children and middle-aged adults could help clarify when this pattern would likely predominate.

Lift or Lift and Reach was observed at low frequencies in both young adults (Sarnacki, 1985) and adolescents. Sarnacki (1985) hypothesized this pattern as the latest pattern to predominate because of its similarity to Symmetrical Reach, hypothesized as the most advanced UE pattern used to rise to standing from supine on the floor (VanSant, 1983). Because of the low incidence of this movement pattern throughout adolescence and young adulthood, however, this movement

pattern may not represent a developmental step. Further cross-sectional study of other age groups could clarify whether the Lift or Lift and Reach pattern is a step within the developmental sequence.

Based upon the movement pattern frequencies observed in this study and in Sarnacki's (1985) study of young adults, the likely order of predominance of the Lateral Lift and Push, Push, and Double Push patterns appears to be Double Push, Push, and Lateral Lift and Push successively. To determine whether the Lift and Push pattern likely predominates before Double Push or after Lateral Lift and Push, the sequence ordering was examined using the adjacency criterion. When the movement patterns were ordered Double Push, Push, Lateral Lift and Push, and Lift and Push, there were twelve subjects who varied to non-adjacent movement patterns. When the patterns were ordered Lift and Push, Double Push, Push, and Lateral Lift and Push, only two subjects varied to non-adjacent movement patterns. This author therefore chose to hypothesize the latter sequence to represent the order of predominance of the FUE movement patterns.

Therefore, Sarnacki's (1985) hypothesized developmental sequence was not supported. As a result of the present study, the developmental sequence for the FUE for the period leading up to adolescence and into the middle adult years is hypothesized to be in successive order: Lift and Push, Double Push, Push, and Lateral Lift and Push (see Table 23).

Near upper extremity. Sarnacki (1985) hypothesized that the NUE movement patterns would become predominant in the following order: Lateral Lift and Push, Grasp and Push, and Push. Lateral Lift and Push is likely an early predominating pattern because of its sharp decrease

Table 23

Proposed Movement Pattern Developmental Sequences for the Task of Rising From a Bed

| | |
|---|---|
| Far Upper Extremity: | 4-Lift and Push |
| | 3-Double Push |
| | 2-Push |
| | 1-Lateral Lift and Push |
| Near Upper Extremity: | 1-Lateral Lift and Push |
| | 3-Push |
| | 2-Grasp and Push |
| Head and Trunk: | 1-Pelvis Leading |
| | 2-Lateral Roll |
| | 4-Come to Sit |
| | 3-Roll-Off |
| Lower Extremities: | 2-Asynchronous With Leg Extension |
| | 1-Step-Off |
| | 2-Asynchronous With Leg Extension |
| | 3-Asynchronous |
| | 4-Synchronous |

Note. The Far Upper Extremity Lift or Lift and Reach and the Near Upper Extremity Lift and Reach movement patterns are not included in the proposed sequences because these patterns are not believed to be developmental steps.

in frequency between 11-year-olds and 14-year-olds. The limited age-related differences observed among adolescents in the frequency of occurrence of the Grasp and Push and Push patterns did not allow identification of the likely ordering of these two patterns without again referring to Sarnacki's (1985) data.

Because Grasp and Push showed an increased frequency in young adults as compared to 17-year-olds and because Push showed a decreased frequency in young adults as compared to 17-year-olds, the NUE sequence appears to have been misordered. Push would likely predominate before Grasp and Push.

Since Lift and Reach was not observed in young adults and was observed at a very small frequency in adolescents, this pattern may not represent a developmental step. Further cross-sectional study of other age groups, such as children, middle-aged adults, or the elderly, could determine how prevalent this movement pattern is in other age groups.

Based upon the results of this study and Sarnacki's observed frequencies, the hypothesized developmental sequence was not supported. As a result of this study, the developmental sequence for the NUE for the period leading up to adolescence and into the middle adult years is proposed to be in successive order: Lateral Lift and Push, Push, and Grasp and Push (see Table 23).

Head and trunk. Pelvis Leading, Lateral Roll, Roll-Off, and Come to Sit is the successive developmental order hypothesized by Sarnacki (1985) for the HT. Pelvis Leading, observed infrequently among adolescents, was also observed infrequently among young adults. The low incidence of this movement pattern may indicate that this movement pattern is not a developmental step. Sarnacki (1985), however,

hypothesized Pelvis Leading as the first step in the sequence because of its similarity to an early appearing rolling pattern described by McGraw (1945). Further cross-sectional study of other age groups, particularly children, could clarify whether this movement pattern is a developmental step and if this pattern is the earliest pattern to predominate. Based on the results of this study, Pelvis Leading could be the first step in the developmental sequence.

The Lateral Roll pattern, which was less common in 14- and 17-year-olds than in 11-year-olds, also occurred at a low frequency among young adults. This pattern received support as an earlier step in the hypothesized developmental sequence.

Roll-Off, which appeared to be increasing in frequency across adolescence, demonstrated a sharply increased frequency in young adults. Come to Sit reached its peak frequency in 14-year-olds and demonstrated a greatly decreased frequency among young adults. Come to Sit, therefore, appears to be an earlier predominating movement pattern than Roll-Off. This indicates that the sequence proposed by Sarnacki (1985) is probably misordered.

Based on the age-related movement pattern differences observed, Sarnacki's (1985) hypothesized developmental sequence was not supported. The order of development of the HT movement patterns for the period leading up to adolescence and into the middle adult years is hypothesized to be in successive order: Pelvis Leading, Lateral Roll, Come to Sit, and Roll-Off (see Table 23).

Lower extremities. Sarnacki (1985) hypothesized that the developmental sequence for the LE movement patterns was Step-Off, Asynchronous With Leg Extension, Asynchronous, and Synchronous.

Examining the data of young adults was again helpful in determining if Sarnacki's hypothesized sequence was supported in the adolescent study or if a revised sequence was necessary.

Step-Off was not supported as the earliest predominating movement pattern. This pattern, which was less common in 11-year-olds than in 14-year-olds, was the most common movement pattern among 14-year-olds. Step-Off, therefore, appears to be an intermediate step in the sequence.

Asynchronous With Leg Extension was the most common movement pattern in 11- and 17-year-olds. Among young adults, this movement pattern was less common than in 17-year-olds. Asynchronous With Leg Extension may, therefore, represent an early predominating movement pattern in the LE sequence. This pattern may then again become predominant after the Step-Off pattern, as was observed in this study.

Because the Asynchronous and Synchronous patterns varied little in frequency among adolescents, Sarnacki's observation of their incidence in young adults was used to hypothesize their place in the developmental sequence. Asynchronous, which was never common in adolescents, was the most common LE movement pattern in young adults. This trend supports the Asynchronous pattern as a later predominating step in the sequence.

Synchronous occurred infrequently in adolescents and young adults. Whether this pattern is a later predominating movement pattern would require further cross-sectional study of an older age group of subjects, such as middle-aged adults. Synchronous is hypothesized, however, as the last step in the sequence because of its similarity to the Symmetrical Squat pattern, hypothesized to be the most advanced LE movement pattern used to rise to standing from the floor (VanSant, 1983).

Based upon the movement pattern frequencies observed in this study and in Sarnacki's study of young adults, it appears that the hypothesized developmental sequence for the LEs was correctly ordered but did not account for the finding that Asynchronous With Leg Extension might predominate just prior to when the four step sequence is observed. The developmental sequence for the LEs is proposed to be in successive order for the period leading up to adolescence and into the middle adult years: Asynchronous With Leg Extension, Step-Off, Asynchronous With Leg Extension, Asynchronous, and Synchronous (see Table 23).

## Most Common Movement Pattern Combination

The tremendous amount of intra-individual and inter-individual variability in the movement pattern combinations used by adolescents when getting out of bed was evidenced by the large number of different movement pattern combinations observed, by the small incidences of the most common combinations, and by the fact that no subject evidenced the same movement pattern combination across ten trials. This variability indicates that adolescents have available to them a number of different movement pattern combinations when getting out of bed.

Biomechanical constraints may, however, restrict the number of possible movement pattern combinations (Sarnacki, 1985). For example, for a subject to simultaneously demonstrate a Lateral Roll pattern in the HT and a Lift and Reach pattern in the NUE would be unlikely. Once in sidelying, for the subject to move toward sitting without pushing or grasping on the bed with the NUE would be difficult.

The greatest variability was observed in 11-year-olds and was evidenced in three ways. First, the 11-year-olds demonstrated more movement pattern combinations than 14- or 17-year-olds. They also demonstrated three common movement pattern combinations, compared to two in 14-year-olds, and one in 17-year-olds. Finally, the most common movement pattern combinations observed among 11-year-olds were observed less frequently compared to the most common movement pattern combinations demonstrated by 14- or 17-year-olds. This greater variability among younger subjects may indicate that younger adolescents are undergoing a period of more rapid developmental change than older adolescents who may be demonstrating more advanced movement patterns (VanSant, 1983).

One of the three movement pattern combinations demonstrated commonly by 11-year-olds was the same as one of the two combinations demonstrated commonly by 14-year-olds and the most common combination demonstrated by 17-year-olds. The similarities in common movement pattern combinations for each age group suggest that the age intervals chosen for this study may have been too small. Age differences in the most common movement pattern combinations may have been greater if larger age intervals, perhaps four or five years, had been selected.

The most common movement pattern combinations of adolescents (see Figures 17-20) differed from the one reported by Sarnacki (1985) in young adults (see Figure 7). This is an additional indicator that there are developmental differences in the movement pattern combinations used to get out of bed.

Universality and Intransitivity of Hypothesized Developmental Sequences

For each body region, there were subjects who varied to non-adjacent movement patterns in the hypothesized and revised sequences. For the FUE, NUE, HT, and LE regions, no ordering was possible where subjects varied only to adjacent movement patterns. There are several reasons why this may have been so.

One plausible explanation is that subjects who varied to non-adjacent movement patterns may have already achieved the most advanced levels in the hypothesized sequence for a body region (Richter, 1985). These subjects, therefore, may have varied among non-adjacent movement patterns because all movement patterns were available to them. Further study of a younger age group would be needed to determine if younger subjects appear to be progressing through a developmental sequence in this task.

Another possible explanation may be that the movement pattern categories that Sarnacki (1985) identified do not represent developmental steps. For example, several subjects violated the adjacency criterion for the near upper extremity. Sarnacki described separate developmental sequences for the UEs. Further investigation would be needed to determine if movement pattern descriptions could be generated for the UEs as a single body region and if a developmental sequence could be hypothesized for this region. Other studies identifying the movement patterns used for various righting tasks, such as coming to standing from supine on the floor (VanSant, 1983), rolling (Richter, 1985), and rising to standing from a chair (Francis, 1987) have generated a single sequence for the UEs.

A third explanation is that all individuals do not progress through a single developmental sequence in the same order. This possibility would contradict stage theory predictions. If most, but not necessarily all, individuals progress through a sequence in the same order, another theory would be needed to explain developmental change (Roberton et al., 1980). Under such a theory, one individual who varied to a non-adjacent movement pattern would not necessarily invalidate a developmental sequence.

## Conclusions

The following are conclusions of this study:

1) Descriptions of the movement patterns used by young adults getting out of bed describe most of the movement patterns used by adolescents when performing this task.

2) There are age-related differences in the movement patterns used by adolescents to rise to standing from supine on a bed.

3) Great intra-individual and inter-individual variability exists in the movement patterns and movement pattern combinations demonstrated by adolescents when getting out of bed.

4) Developmental sequences of movement patterns for the task of rising to standing from supine on a bed are not universal and invariant across adolescence.

## Implications of This Study

Physical therapists frequently treat patients who are unable to get out of bed. Knowledge of the wide variety of movement patterns used to get out of bed should allow therapists to choose from a variety of

movement patterns when teaching this activity. Knowing that there are age-related differences in the movement patterns used to get out of bed, therapists can then select age-appropriate patterns to teach their adolescent or young adult patients.

The movement patterns used by patients to get up from bed may eventually be easily classified in a clinical setting. When working with patients, therapists can observe the movement patterns demonstrated by their patients from either side or foot views as was done in this study. Videotaping could also be used to provide supportive, objective documentation of patients' movement patterns.

## Recommendations for Future Studies

Suggestions for future studies have been presented throughout this chapter. Additional suggestions follow.

Subjects in the present study were all asked to come to standing from a supine position on a bed. This was consistent with the starting position used by the young adults in Sarnacki's (1985) study. Further studies could examine the movement patterns used by individuals to come to standing from starting positions other than supine with the arms and legs extended. Altering the starting position would likely affect the movement patterns demonstrated.

Additionally, a study examining the movement patterns used to get out of bed by individuals with various physical disabilities is recommended. Such a study could determine if individuals with physical disabilities demonstrate the same movement patterns when getting out of bed as individuals without physical disabilities.

## Summary

The purposes of this study were to determine: 1) if movement patterns described for young adults coming to standing from supine on a bed comprehensively depicted the movements used by adolescents, 2) if age-related differences existed in the movement patterns demonstrated by adolescents in each of four body regions corresponding to hypothesized developmental sequences, 3) the most common movement pattern combination for each age group, and 4) if individual movement pattern variability was only to adjacent steps in the hypothesized sequences.

Sixty adolescents, 11, 14, or 17 years of age, were videotaped during 10 trials of rising to standing from supine on a bed. The movement patterns demonstrated in each body region, the Far Upper Extremity, Near Upper Extremity, Head and Trunk, and Lower Extremities, were categorized, and new movement patterns were described. The frequency of occurrence of each movement pattern and the most common movement pattern combination were determined for each age group.

Except for one new movement pattern observed at the NUE, the movement patterns described for young adults comprehensively depicted the movement patterns demonstrated by adolescents. Age-related movement pattern differences were present in each body region. Hypothesized developmental sequences were not supported for the FUE, NUE, and HT body regions, and revised developmental sequences were proposed. The hypothesized developmental sequence for the LEs appears to have been ordered correctly but did not account for the finding that one of the LE movement patterns might predominate just prior to when the proposed four step sequence is observed. Great intra-individual and inter-individual variability existed in the number of movement pattern

combinations demonstrated. Three movement pattern combinations were commonly demonstrated by 11-year-olds, two by 14-year-olds, and one by 17-year-olds. One of these combinations was the same for all three age groups. The hypothesis that individual movement pattern variability would only occur among adjacent steps in a developmental sequence was not supported.

In conclusion, descriptions of the movement patterns used by young adults to get out of bed describe most of the movement patterns used by adolescents performing the same task. Age-related differences exist in the movement patterns used by adolescents to rise to standing from supine on a bed. Adolescents demonstrate great intra-individual and inter-individual movement pattern variability when getting out of bed. The movement patterns used to get out of bed do not develop in a universal and invariant order across adolescence.

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# Appendices

Appendix A

Sample Letter to School Principal

Date: _____

Dear _____,

I am a physical therapist and graduate student in the Physical Therapy Department of the Medical College of Virginia (MCV)/Virginia Commonwealth University. I am completing a research thesis under the direction of Ann F. VanSant, Ph.D., P.T., Associate Professor of Physical Therapy. My proposal has been approved by the graduate faculty of the Physical Therapy Department here at MCV.

I am studying the movements used by healthy adolescents 11, 14, and 17 years of age to come to standing from a bed. This information is important to physical therapists who must teach adolescents with physical disabilities how to get out of bed.

Would you be willing to have students from your school participate in this project? I hope to study a total of 60 adolescents, 20 from each of three age groups: 11, 14, and 17 year old adolescents. Each student would be videotaped while coming to standing from a bed ten consecutive times. The videotapes would only be used for teaching and research purposes, and the students' names would not be used with any report of the study.

With your permission, I would first send home with students in these age groups an explanatory letter and consent form for their parents/guardians. The consent forms for parents/guardians and students have been written in accordance with the guidelines from the MCV Committee for the Conduct of Human Research.

The total data collection process would take approximately five minutes of each student's time. All videotaping times would be arranged at your convenience to minimize disruptions in the school day. I have all of the video equipment and the twin bed needed for the study but would need some videotaping space.

Thank you so much for your time and interest. I will call on _____ to speak with you further about this study. Please feel free to contact me at [redacted] or Dr. VanSant at [redacted] before this date with any questions or concerns that you might have.

Again, thank you for your time and consideration. I look forward to talking with you!

Sincerely,

Jeanne M. O'Neil

# Appendix B

## Sample Letter to Parents/Guardians and Consent Form to Parents

### Sample Letter to Parents/Guardians

Date: _____

Dear Parent/Guardian,

I am a physical therapist and graduate student in Physical Therapy at the Medical College of Virginia/Virginia Commonwealth University. Under the direction of Ann F. VanSant, Ph.D., P.T., Associate Professor of Physical Therapy, I am completing my graduate thesis. I am studying the movements that healthy 11, 14, and 17 year old adolescents use to come to standing from a bed. Physical therapists teach adolescents with physical disabilities how to perform various basic activities, such as getting out of bed. The results of this study, therefore, will be valuable to physical therapists, particularly to physical therapists working with persons about the age of your son/daughter.

If your son/daughter is 11, 14, or 17 years of age, would you allow him/her to participate in this study? He/she would be videotaped while coming to standing from a bed 10 consecutive times. The total study will take approximately five minutes of each student's time. M_. _____ at _____ school has given me permission to videotape at the school. Videotaping times will be arranged to minimize disruptions in the regular school schedule. Your

son/daughter's name would not be used in any report of the study, and the videotapes would only be used for teaching and research purposes.

If you are willing to have your son/daughter participate, please sign and complete the enclosed consent form and return it to the school as soon as possible. On the day of the study, please remind your son/daughter to wear comfortable clothing (shirts and slacks or shorts). Your son/daughter may withdraw, or you may withdraw your son/daughter, from this study at any time and for any reason.

Thank you so much for your time and interest. Please feel free to contact me at [redacted] or Dr. VanSant at [redacted] if you have any additional questions or concerns.

Again, thank you!

Sincerely,

Jeanne M. O'Neil

# Parental Consent Form

Jeanne M. O'Neil has permission to include my son/daughter in a study describing the movements that 11, 14, and 17 year olds use to come to standing from a bed. This information will be useful to help physical therapists teach persons with physical disabilities how to get out of bed.

I understand that my son/daughter will be videotaped coming to standing from a bed 10 consecutive times. I understand that my son/daughter's name will not be used in any report of the study. I understand that the videotapes will only be used for teaching and research purposes.

The purpose and procedures of this study have been fully explained to my son/daughter and me. My questions have been answered. To the best of my knowledge, my son/daughter has no physical problems that alter the way he/she gets out of bed.

I understand that my son/daughter may withdraw from this study, or that I may withdraw him/her from this study, at any time and for any reason. I will be given a copy of this consent form if I request one.

Signature:_____ Name:_____

(Parent or Guardian) (Son/Daughter's)

Son/Daughter's Age:_____ Date of Birth:_____/_____/_____

Witness:_____ Date:_____

Appendix C

## Subject Consent Form

Jeanne M. O'Neil has my permission to include me in a study looking at the way young people come to standing from a bed. Information from this study will be helpful to physical therapists who teach persons with physical problems how to get out of bed.

I understand that I will be videotaped as I come to standing from a bed 10 times. I understand that my name will not be used in any reports of this project. I understand that my videotapes may be used for teaching and research purposes.

The purpose and procedures of this study have been explained to me. My questions have been answered. I understand that I may withdraw from this study at any time and for any reason. I will be given a copy of this consent form if I request one.

Signature:_____ Date:_____

Name:_____ Age:____ Date of Birth:_____

Witness:_____

Appendix D

## Subject Instruction Checklist

Subject #:

1) Parental consent?

2) Introduce assistant.

3) Ask if any bone or joint, nerve, heart, lung, or other problems make it hard to get out of bed: eg. arm, leg, or spine problems or old sport injuries.

4) Explain study:
   a) Videotape subject getting out of bed.
   b) Tapes for teaching & research only. No names will be used.

5) What the subject will do:
   a) Remove shoes and socks.
   b) Lie on the bed on back with arms at sides.
   c) Get up from the bed as quickly as possible and stay standing until asked to lie back down.
   d) May request to rest briefly between trials if needed.
   e) Repeat 10 times.

6) What I'll say:
   a) "Ready" - Videotape on.
   b) "Go" - Get up.

7) Any questions?

8) Subject consent form:
   a) Read carefully and sign.
   b) Print name, age, & DOB.

9) Witness & subject #.

# Appendix E

## Videotaping Errors

1) For Subject 1, the first trial 1 was voided.
2) For Subject 6, the first trials 1-8 and the second trials 1 and 2 were used in this study as the subject's 10 trials.
3) For Subject 10, trials 1 through 6, both trials 7's, and trials 8 and 9 were used in this study as the subject's 10 trials.
4) Subject 14 has two sets of data on the side view videotape. Trials 1 to 10 on the foot view videotape and the second set of trials 1 to 10 on the side view videotape were used in this study as the subject's 10 trials.
5) Subject 15 for the first eight trials was wrongly identified as Subject 13.
6) For Subject 16, the first trial 3 was voided.
7) For Subject 26, the 10 trials used in this study were both trial 1's, trials 2 through 8, and trial 10 on the videotape.
8) For Subject 28, the first trial 1 was voided.
9) For Subject 37, the ten trials used in this study were trials 1 through 5, the first trial 6, both trial 7's, and trials 8 and 9 on the videotape.
10) For Subject 38, the first trial 1 was voided.
11) For Subject 40, the first trial 1 was voided.

## Appendix F

## Decision Rules Used to Categorize Movement Patterns

A lettering system was used by Sarnacki (1985) to identify the movement patterns. Numbers have been used here to indicate the order in which Sarnacki hypothesized the movement patterns would develop. For reading ease, the name of the movement pattern is generally used instead of referring to the movement pattern by number or letter.

### Far Upper Extremity

1) Decision between categories 1-Lateral Lift and Push and 2-Push:
   a) If the FUE is blocked from view by the LEs and the pattern is either Lateral Lift and Push or Push, classify the movement as Push (Sarnacki, 1985).
   b) If the FUE lifts and then returns to the starting position to push, classify the pattern as Push.
   c) If it is difficult to determine if the pattern is Lateral Lift and Push or Push, classify the movement as Push (Sarnacki, 1985).
2) For categories 2-Push and 3-Double Push: If the subject pushes on the elbow and then on the hand without lifting the arm, consider the movement a single push.
3) For categories 3-Double Push and 4-Lift and Push:
   a) If the subject pushes on the anterior thigh instead of the bed, consider the movement as a push.
   b) If the subject pushes on the opposite side of the body just before coming to standing, consider the movement a push.

(Continued)

Appendix F (Continued)

Decision Rules

Near Upper Extremity

1) Decision between categories 1-Lateral Lift and Push and 3-Push:
   a) If the NUE pushes on the bed, then lifts to readjust position and pushes again, classify the movement as Push (Sarnacki, 1985).
   b) If the subject lifts the NUE and then returns to the starting position to push, classify the movement as Push.
   c) If it is difficult to determine if the pattern is Lateral Lift and Push or Push, classify the pattern as Push.
2) For category 1-Lateral Lift and Push: If the subject lifts or slides the upper extremity toward the head of the bed and then pushes, classify the movement as Lateral Lift and Push even if the wrist, instead of the hand, is the last part of the extremity to lift off of the bed.
3) For category 2-Grasp and Push:
   a) If the hand grabs the edge of the bed at any time during the movement, classify the movement as Grasp and Push (Sarnacki, 1985).
   b) If the subject grabs the leg, but not the bed, do not classify the movement as Grasp and Push.

(Continued)

Appendix F (Continued)

Decision Rules

Head and Trunk

1) Decision between category 2-Lateral Roll and categories 3-Roll-Off and 4-Come to Sit:

   a) When the subject reaches side-facing, at the point of highest elevation of the pelvis, if there is no space between the NUE and the trunk, classify the movement as Lateral Roll.

   b) When the subject reaches side-facing, at the point of highest elevation of the pelvis, if there is a space between the NUE and the trunk, classify the movement as Roll-Off or Come to Sit, depending on the amount of head and trunk displacement toward the head of the bed when the buttocks come off the bed (See decision rule 2).

2) Decision between categories 3-Roll-Off and 4-Come to Sit (These decision rules were modified from Sarnacki (1985) to be applicable to persons rising toward either the right or left side of the bed. The original intent of the decision rules was not changed.):

   a) When the buttocks come off the bed, if the nose is aligned with or lateral to the lateral border of the hip nearest the head of the bed, classify the movement as Roll-Off. If the hip is obscured, use the waist as a guide.

(Continued)

Appendix F (Continued)

Decision Rules

b) When the buttocks come off the bed, if the nose is medial to the lateral border of the hip nearest the head of the bed, classify the movement as Come to Sit.

c) If it is difficult to determine whether the movement is Roll-Off or Come to Sit, classify the movement as Roll-Off.

Lower Extremities (The lower extremity decision rules were modified from Sarnacki (1985) to be applicable to persons rising toward either the right or left side of the bed. The original intent of the decision rules was not changed.)

1) Category 1-Step-Off:

   a) The far thigh is above the near thigh if a space is seen between them.

   b) If the far thigh is above the near thigh, and the far foot is in front of the near leg, classify the movement as Step-Off.

2) Category 2-Asynchronous With Leg Extension: The far foot is in front of the near leg if a space is seen between them.

3) Categories 2-Asynchronous With Leg Extension and 3-Asynchronous: The thighs are parallel if no space is seen between them.

Appendix G

Trial by Trial Movement Pattern Categorizations

Table 6

Far Upper Extremity (F), Near Upper Extremity (N), Head and Trunk (T), and Lower Extremity (L) Movement Pattern Categorizations for Subjects 11 Years of Age

| | Trial (N = 200) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Subject Number | 1 FNTL | 2 FNTL | 3 FNTL | 4 FNTL | 5 FNTL | 6 FNTL | 7 FNTL | 8 FNTL | 9 FNTL | 10 FNTL |
| 21 | 3132 | 3322 | 3323 | 3133 | 4333 | 3344 | 3322 | 3344 | 3321 | 3332 |
| 25 | 2143 | 2142 | 2143 | 2343 | 2243 | 2123 | 2132 | 2343 | 2332 | 2332 |
| 26 | 3343 | 3344 | 2334 | 2323 | 2322 | 3342 | *3342 | *4344 | 2322 | 2322 |
| 27 | °4122 | 3142 | 3132 | 3122 | 3132 | 3132 | 3122 | *3132 | 2323 | 3323 |
| 28 | 3343 | 3331 | 3343 | 3341 | 3342 | 3322 | 3242 | 3121 | 3243 | 3243 |
| 29 | 2242 | 2242 | 1244 | 2344 | 2244 | 2244 | 3244 | 1244 | 3344 | 3344 |
| 30 | 3242 | 3243 | 3242 | 3242 | 3242 | 3242 | 3242 | 3242 | 3342 | 3242 |
| 31 | 3243 | 3243 | 3132 | 3222 | 3243 | 3143 | 3143 | 3222 | 4243 | 4123 |
| 32 | 3143 | 4133 | 4343 | 4343 | 4143 | 3344 | 3344 | 3234 | 3142 | 3142 |
| 33 | 3242 | 3223 | 4333 | 3221 | 4122 | 4221 | 3223 | 3342 | 3222 | 4223 |
| 34 | 3233 | 3241 | 3244 | 3244 | 3241 | 3241 | 3241 | 3242 | 3234 | 3244 |
| 35 | 3212 | 3213 | 3213 | 3213 | 3213 | 3212 | 3213 | 3212 | 3213 | 3212 |
| 36 | 3223 | 3222 | 3222 | 3223 | 3221 | 3222 | 3222 | 3222 | 3222 | 3222 |
| 37 | 3232 | 3232 | 3133 | 3133 | 3132 | 3142 | 3142 | 3131 | 3131 | 3142 |
| 38 | 2121 | 4322 | 4222 | 5343 | 5123 | 4443 | 2122 | 5323 | 2323 | 5321 |
| 39 | 3323 | 3122 | 3322 | 3121 | 3322 | 3321 | 3321 | 3321 | 2322 | 3323 |
| 40 | 2133 | 2143 | 2333 | 2343 | 2343 | 2133 | 2333 | 3342 | 3342 | 3343 |
| 41 | 3122 | 3142 | 3144 | 3144 | 3324 | 3323 | 3344 | 2322 | 1324 | 3323 |
| 42 | 3243 | 3233 | 3322 | 3331 | 3322 | 3222 | 3242 | 3142 | 3241 | 3242 |
| 58 | 3332 | 3332 | *3322 | *3322 | 3322 | *3322 | *3342 | 3123 | *3122 | *3132 |

*Trials with a push of the Far Upper Extremity on the leg.
°Trial with a push of the Near Upper Extremity on the leg.

Far Upper Extremity Movement Patterns: 1-Lateral Lift and Push; 2-Push; 3-Double Push; 4-Lift and Push; 5-Lift or Lift and Reach.

Near Upper Extremity Movement Patterns: 1-Lateral Lift and Push; 2-Grasp and Push; 3-Push; 4-Lift and Reach.

Head and Trunk Movement Patterns: 1-Pelvis Leading; 2-Lateral Roll; 3-Roll-Off; 4-Come to Sit.

Lower Extremity Movement Patterns: 1-Step-Off; 2-Asynchronous With Leg Extension; 3-Asynchronous; 4-Synchronous.

Table 7

Far Upper Extremity (F), Near Upper Extremity (N), Head and Trunk (T), and Lower Extremity (L) Movement Pattern Categorizations for Subjects 14 Years of Age

| | Trial (N = 200) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Subject Number | 1 FNTL | 2 FNTL | 3 FNTL | 4 FNTL | 5 FNTL | 6 FNTL | 7 FNTL | 8 FNTL | 9 FNTL | 10 FNTL |
| 14 | 3341 | 3242 | 3243 | 3243 | 3244 | 3241 | 3243 | 3341 | 3242 | 3241 |
| 16 | 2323 | 2323 | 2323 | 2323 | 2323 | 2323 | 2323 | °2323 | °2321 | 2323 |
| 17 | 3242 | 3221 | 3223 | 3241 | 3241 | 3242 | 3243 | 3241 | 3241 | 3122 |
| 20 | 3243 | 3243 | 3143 | 3143 | 3341 | 3341 | 3341 | 3341 | 3341 | 3341 |
| 22 | 3243 | 3243 | 3242 | 3244 | 3244 | 3244 | 2244 | 3241 | 3241 | 3243 |
| 24 | 3242 | 3231 | 3231 | 3142 | 3241 | 3242 | 3231 | 3141 | 3241 | 3242 |
| 43 | 3243 | 3243 | 3243 | 3244 | 3242 | 3244 | 3241 | 3244 | 2243 | 2244 |
| 44 | 3142 | 3342 | 3342 | 3342 | 3142 | 3342 | 3342 | 4332 | 3332 | 3132 |
| 45 | 3243 | 3242 | 3244 | 3244 | 3141 | 3141 | 3244 | 3244 | 3142 | 3141 |
| 46 | 3241 | 3241 | 3241 | 3241 | 3241 | 3241 | 3243 | 3243 | 3241 | 3242 |
| 47 | 3242 | 3242 | 3344 | 3344 | 3344 | 3344 | 3344 | 3344 | 3344 | 3344 |
| 48 | 2344 | 2343 | 2342 | 2341 | 2342 | 2341 | 2322 | 2342 | 2341 | 2341 |
| 49 | 3343 | 3243 | 3143 | 3343 | 3333 | 3242 | 3243 | 3343 | 3143 | 3142 |
| 50 | 3241 | 2241 | 2341 | 2331 | 2331 | 3331 | 3331 | 3231 | 2231 | 3331 |
| 51 | 3241 | 3232 | 3232 | 3243 | 3233 | 3242 | 3242 | 3242 | 3242 | 2242 |
| 52 | 3143 | 3133 | 2144 | 2341 | 3342 | 3344 | 3341 | 3341 | 3344 | 3344 |
| 57 | 3241 | 3331 | 3341 | 3231 | 3241 | 3241 | 3242 | 3331 | 3232 | 3331 |
| 59 | 3343 | 3323 | +3323 | 3343 | 3322 | 3322 | 3343 | 2322 | 3342 | 2321 |
| 60 | 3242 | 3233 | 3232 | 3232 | 3131 | 3242 | 3241 | 3241 | 3242 | 3242 |
| 61 | 3332 | 3342 | 3333 | 3342 | 3343 | 3343 | 3344 | 3342 | 3343 | 3343 |

+Trial with second push of the Far Upper Extremity on the opposite side of the body.

°Trials with a push of the Near Upper Extremity on the leg.

Far Upper Extremity Movement Patterns: 1-Lateral Lift and Push; 2-Push; 3-Double Push; 4-Lift and Push; 5-Lift or Lift and Reach.

Near Upper Extremity Movement Patterns: 1-Lateral Lift and Push; 2-Grasp and Push; 3-Push; 4-Lift and Reach.

Head and Trunk Movement Patterns: 1-Pelvis Leading; 2-Lateral Roll; 3-Roll-Off; 4-Come to Sit.

Lower Extremity Movement Patterns: 1-Step-Off; 2-Asynchronous With Leg Extension; 3-Asynchronous; 4-Synchronous.

Table 8

Far Upper Extremity (F), Near Upper Extremity (N), Head and Trunk (T), and Lower Extremity (L) Movement Pattern Categorizations for Subjects 17 Years of Age

| Subject Number | Trial (N = 200) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 FNTL | 2 FNTL | 3 FNTL | 4 FNTL | 5 FNTL | 6 FNTL | 7 FNTL | 8 FNTL | 9 FNTL | 10 FNTL |
| 1 | 3242 | 3242 | 3222 | 3242 | 4142 | 3342 | 3232 | 3242 | 4142 | 4142 |
| 2 | 3243 | 3233 | 3233 | 3233 | 3232 | 3232 | 3233 | 3243 | 3232 | 3232 |
| 3 | 2241 | 2342 | 3241 | 3242 | 3242 | 3232 | 3241 | 3241 | 3231 | 3242 |
| 4 | 3243 | 3242 | 3242 | 3242 | 3242 | 3242 | 3242 | 3242 | 3242 | 3242 |
| 6 | 2333 | 3344 | 3344 | 3342 | 3344 | 3344 | 3344 | 3344 | 3344 | 3342 |
| 7 | 3143 | 2243 | 2233 | 2243 | 2243 | 2243 | 2243 | 2232 | 2242 | 2242 |
| 8 | 4343 | 4343 | 4343 | 4343 | 2333 | 2343 | 3342 | 4333 | 4342 | 4443 |
| 9 | 3343 | 3242 | 3342 | 3342 | 3342 | 3342 | 3342 | 3342 | 3342 | 3342 |
| 10 | 3343 | 3343 | 3343 | 3243 | 3242 | 3243 | 3242 | 3243 | 3243 | 2232 |
| 11 | 3143 | 4143 | 4143 | 3142 | 4143 | 4143 | 4142 | 4143 | 4143 | 4242 |
| 12 | 2333 | 2333 | 2333 | 3333 | 2331 | 2333 | 2334 | 3334 | 2334 | 2334 |
| 13 | 2342 | 2322 | 4343 | 3323 | 2334 | 3341 | 3344 | 3341 | 3343 | 3341 |
| 15 | 2342 | 5333 | *4333 | °5333 | °5331 | °5331 | °5331 | °5343 | °*4333 | °5341 |
| 18 | 3341 | 3241 | 3341 | 3341 | 3341 | 3141 | 3141 | 3141 | 3141 | 3341 |
| 19 | 3242 | 3242 | 3241 | 3241 | 3241 | 3241 | 3241 | 3241 | 3241 | 3242 |
| 23 | 3242 | 2242 | 2242 | 2242 | 3242 | 3242 | 3242 | 3242 | 3232 | 3242 |
| 53 | 2333 | 2333 | 2332 | 2332 | 2332 | 2332 | 2332 | 2342 | 2333 | 2232 |
| 54 | 3342 | 3242 | 3232 | 3241 | 3131 | 4242 | 4241 | 4242 | 4241 | 4242 |
| 55 | 3142 | 3312 | 3312 | 3312 | 3312 | 3312 | 3312 | 3312 | 3312 | 3312 |
| 56 | 3143 | 3132 | 3342 | 3343 | 3342 | 3243 | 3344 | 3342 | 3342 | 3342 |

*Trials with a push of the Far Upper Extremity on the leg.
°Trials with a push of the Near Upper Extremity on the leg.

Far Upper Extremity Movement Patterns: 1-Lateral Lift and Push; 2-Push; 3-Double Push; 4-Lift and Push; 5-Lift or Lift and Reach.

Near Upper Extremity Movement Patterns: 1-Lateral Lift and Push; 2-Grasp and Push; 3-Push; 4-Lift and Reach.

Head and Trunk Movement Patterns: 1-Pelvis Leading; 2-Lateral Roll; 3-Roll-Off; 4-Come to Sit.

Lower Extremity Movement Patterns: 1-Step-Off; 2-Asynchronous With Leg Extension; 3-Asynchronous; 4-Synchronous.

Appendix H

Movement Pattern Combination Percent Occurrences Across Trials

Table 15

Movement Pattern Combination Percent Occurrences (%) Observed in Subjects 11 Years of Age (N = 200 trials)

| FNTL | % | FNTL | % | FNTL | % | FNTL | % |
|---|---|---|---|---|---|---|---|
| 3242 | 6.5 | 3321 | 2.0 | 3232 | 1.0 | 3324 | 0.5 |
| 3322 | 5.5 | 3343 | 2.0 | 3233 | 1.0 | 3341 | 0.5 |
| 3222 | 5.5 | 2143 | 1.5 | 3234 | 1.0 | 4123 | 0.5 |
| 3132 | 4.0 | 2323 | 1.5 | 3331 | 1.0 | 4133 | 0.5 |
| 3142 | 4.0 | 3133 | 1.5 | 4122 | 1.0 | 4143 | 0.5 |
| 3342 | 4.0 | 3143 | 1.5 | 4333 | 1.0 | 4221 | 0.5 |
| 3344 | 4.0 | 3332 | 1.5 | 4343 | 1.0 | 4222 | 0.5 |
| 3243 | 3.5 | 1244 | 1.0 | 1324 | 0.5 | 4223 | 0.5 |
| 3213 | 3.0 | 2133 | 1.0 | 2121 | 0.5 | 4243 | 0.5 |
| 3323 | 3.0 | 2242 | 1.0 | 2122 | 0.5 | 4322 | 0.5 |
| 3122 | 2.5 | 2244 | 1.0 | 2123 | 0.5 | 4344 | 0.5 |
| 3241 | 2.5 | 2332 | 1.0 | 2132 | 0.5 | 4443 | 0.5 |
| 2322 | 2.5 | 2333 | 1.0 | 2142 | 0.5 | 5123 | 0.5 |
| 2343 | 2.0 | 3121 | 1.0 | 2243 | 0.5 | 5321 | 0.5 |
| 3212 | 2.0 | 3131 | 1.0 | 2334 | 0.5 | 5323 | 0.5 |
| 3223 | 2.0 | 3144 | 1.0 | 2344 | 0.5 | 5343 | 0.5 |
| 3244 | 2.0 | 3221 | 1.0 | 3123 | 0.5 | | |

Note. F = Far Upper Extremity.
N = Near Upper Extremity.
H = Head and Trunk.
L = Lower Extremities.

Far Upper Extremity Movement Patterns: 1-Lateral Lift and Push; 2-Push; 3-Double Push; 4-Lift and Push; 5-Lift or Lift and Reach.

Near Upper Extremity Movement Patterns: 1-Lateral Lift and Push; 2-Grasp and Push; 3-Push; 4-Lift and Reach.

Head and Trunk Movement Patterns: 1-Pelvis Leading; 2-Lateral Roll; 3-Roll-Off; 4-Come to Sit.

Lower Extremity Movement Patterns: 1-Step-Off; 2-Asynchronous With Leg Extension; 3-Asynchronous; 4-Synchronous.

Appendix H (Continued)

Table 16

Movement Pattern Combination Percent Occurrences (%) Observed in Subjects 14 Years of Age (N = 200 trials)

| FNTL | % | FNTL | % | FNTL | % | FNTL | % |
|---|---|---|---|---|---|---|---|
| 3241 | 12.5 | 3331 | 3.0 | 2331 | 1.0 | 2243 | 0.5 |
| 3242 | 11.5 | 3142 | 2.5 | 3233 | 1.0 | 2343 | 0.5 |
| 3243 | 9.0 | 3143 | 2.5 | 3322 | 1.0 | 2344 | 0.5 |
| 3344 | 6.0 | 3231 | 2.5 | 3323 | 1.0 | 3122 | 0.5 |
| 3244 | 5.5 | 3232 | 2.5 | 3332 | 1.0 | 3131 | 0.5 |
| 3341 | 5.5 | 3141 | 2.0 | 3333 | 1.0 | 3132 | 0.5 |
| 3342 | 5.0 | 2342 | 1.5 | 2144 | 0.5 | 3133 | 0.5 |
| 3343 | 5.0 | 2244 | 1.0 | 2231 | 0.5 | 3221 | 0.5 |
| 2323 | 4.5 | 2321 | 1.0 | 2241 | 0.5 | 3223 | 0.5 |
| 2341 | 3.0 | 2322 | 1.0 | 2242 | 0.5 | 4332 | 0.5 |

Note. F = Far Upper Extremity.
N = Near Upper Extremity.
T = Head and Trunk.
L = Lower Extremities.

Far Upper Extremity Movement Patterns: 1-Lateral Lift and Push; 2-Push; 3-Double Push; 4-Lift and Push; 5-Lift or Lift and Reach.

Near Upper Extremity Movement Patterns: 1-Lateral Lift and Push; 2-Grasp and Push; 3-Push; 4-Lift and Reach.

Head and Trunk Movement Patterns: 1-Pelvis Leading; 2-Lateral Roll; 3-Roll-Off; 4-Come to Sit.

Lower Extremity Movement Patterns: 1-Step-Off; 2-Asynchronous With Leg Extension; 3-Asynchronous; 4-Synchronous.

Appendix H (Continued)

Table 17

Movement Pattern Combination Percent Occurrences (%) Observed in Subjects 17 Years of Age (N = 200 trials)

| FNTL | % | FNTL | % | FNTL | % | FNTL | % |
|---|---|---|---|---|---|---|---|
| 3242 | 14.5 | 2242 | 2.5 | 3143 | 1.5 | 3131 | 0.5 |
| 3342 | 9.0 | 2243 | 2.5 | 4333 | 1.5 | 3132 | 0.5 |
| 3241 | 6.0 | 2332 | 2.5 | 5331 | 1.5 | 3222 | 0.5 |
| 2333 | 4.5 | 4343 | 2.5 | 3142 | 1.0 | 3231 | 0.5 |
| 3312 | 4.5 | 2334 | 2.0 | 4241 | 1.0 | 3323 | 0.5 |
| 3344 | 4.5 | 2342 | 2.0 | 5333 | 1.0 | 3333 | 0.5 |
| 3232 | 4.0 | 3141 | 2.0 | 2233 | 0.5 | 3334 | 0.5 |
| 3243 | 4.0 | 3233 | 2.0 | 2241 | 0.5 | 4342 | 0.5 |
| 3341 | 4.0 | 4142 | 2.0 | 2322 | 0.5 | 4443 | 0.5 |
| 3343 | 3.0 | 4242 | 2.0 | 2331 | 0.5 | 5341 | 0.5 |
| 4143 | 3.0 | 2232 | 1.5 | 2343 | 0.5 | 5343 | 0.5 |

Note. F = Far Upper Extremity.
N = Near Upper Extremity.
H = Head and Trunk.
L = Lower Extremities.

Far Upper Extremity Movement Patterns: 1-Lateral Lift and Push; 2-Push; 3-Double Push; 4-Lift and Push; 5-Lift or Lift and Reach.

Near Upper Extremity Movement Patterns: 1-Lateral Lift and Push; 2-Grasp and Push; 3-Push; 4-Lift and Reach.

Head and Trunk Movement Patterns: 1-Pelvis Leading; 2-Lateral Roll; 3-Roll-Off; 4-Come to Sit.

Lower Extremity Movement Patterns: 1-Step-Off; 2-Asynchronous With Leg Extension; 3-Asynchronous; 4-Synchronous.

Appendix I

Intra-subject Movement Pattern Variability

Table 19

Subjects Demonstrating Movement Pattern Variability in the Far Upper Extremity (n = 20 subjects in each age group, each performing 10 trials)

| Age Group (Years) | Subject Number | Movement Pattern | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| | | Number of Trials | | | | |
| 11 | 21 | | | 9 | 1 | |
| | 26 | | 5 | 4 | 1 | |
| | 27 | | 1 | 8 | 1 | |
| | 29 | 2 | 5 | 3 | | |
| | 31 | | | 8 | 2 | |
| | 32 | | | 6 | 4 | |
| | 33 | | | 6 | 4 | |
| | 38* | | 3 | | 3 | 4 |
| | 39 | | 1 | 9 | | |
| | 40 | | 7 | 3 | | |
| | 41 | 1 | 1 | 8 | | |
| 14 | 22 | | 1 | 9 | | |
| | 43 | | 2 | 8 | | |
| | 44 | | | 9 | 1 | |
| | 50 | | 5 | 5 | | |
| | 51 | | 1 | 9 | | |
| | 52 | | 2 | 8 | | |
| | 59 | | 2 | 8 | | |
| 17 | 1 | | | 7 | 3 | |
| | 3 | | 2 | 8 | | |
| | 6 | | 1 | 9 | | |
| | 7 | | 9 | 1 | | |
| | 8 | | 2 | 1 | 7 | |
| | 10 | | 1 | 9 | | |
| | 11 | | | 2 | 8 | |
| | 12 | | 8 | 2 | | |
| | 13 | | 3 | 6 | 1 | |
| | 15* | | 1 | | 2 | 7 |
| | 23 | | 3 | 7 | | |
| | 54 | | | 5 | 5 | |

*Subjects who varied to non-adjacent steps in the hypothesized movement pattern developmental sequence.

Far Upper Extremity Movement Patterns: 1-Lateral Lift and Push; 2-Push; 3-Double Push; 4-Lift and Push; 5-Lift or Lift and Reach.

Table 20

Subjects Demonstrating Movement Pattern Variability in the Near Upper Extremity (n = 20 subjects in each age group, each performing 10 trials)

| Age Group (Years) | Subject Number | Movement Pattern | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| | | Number of Trials | | | |
| 11 | 21* | 2 | | 8 | |
| | 25 | 5 | 1 | 4 | |
| | 27* | 8 | | 2 | |
| | 28 | 1 | 3 | 6 | |
| | 29 | | 7 | 3 | |
| | 30 | | 9 | 1 | |
| | 31 | 4 | 6 | | |
| | 32 | 5 | 1 | 4 | |
| | 33 | 1 | 7 | 2 | |
| | 37 | 8 | 2 | | |
| | 38 | 3 | 1 | 5 | |
| | 39* | 2 | | 8 | |
| | 40* | 3 | | 7 | |
| | 41* | 4 | | 6 | |
| | 42 | 1 | 6 | 3 | |
| | 58* | 3 | | 7 | |
| 14 | 14 | | 8 | 2 | |
| | 17 | 1 | 9 | | |
| | 20 | 2 | 2 | 6 | |
| | 24 | 2 | 8 | | |
| | 44* | 3 | | 7 | |
| | 45 | 4 | 6 | | |
| | 47 | | 2 | 8 | |
| | 49 | 3 | 3 | 4 | |
| | 50 | | 4 | 6 | |
| | 52* | 3 | | 7 | |
| | 57 | | 6 | 4 | |
| | 60 | 1 | 9 | | |
| 17 | 1 | 3 | 6 | 1 | |
| | 3 | | 9 | 1 | |
| | 7 | 1 | 9 | | |
| | 8 | | | 9 | |
| | 9 | | 1 | 9 | |
| | 10 | | 7 | 3 | |
| | 11 | 9 | 1 | | |
| | 18 | 4 | 1 | 5 | |
| | 53 | | 1 | 9 | |
| | 54 | 1 | 8 | 1 | |
| | 55* | 1 | | 9 | |
| | 56 | 2 | 1 | 7 | |

(Continued)

Table 20 (Continued)

Subjects Demonstrating Movement Pattern Variability in the Near Upper Extremity (n = 20 subjects in each age group, each performing 10 trials)

Note. Lift and Reach, a new movement pattern observed in this study, was not a pattern in the developmental sequence hypothesized by Sarnacki. Subjects 38 and 8 each demonstrated this pattern on one trial.

*Subjects who varied to non-adjacent steps in the hypothesized movement pattern developmental sequence.

Near Upper Extremity Movement Patterns: 1-Lateral Lift and Push; 2-Grasp and Push; 3-Push.

Table 21

Subjects Demonstrating Movement Pattern Variability in the Head and Trunk (n = 20 subjects in each age group, each performing 10 trials)

| Age Group (Years) | Subject Number | Movement Pattern | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| | | Number of Trials | | | |
| 11 | 21 | | 4 | 4 | 2 |
| | 25 | | 1 | 3 | 6 |
| | 26 | | 4 | 1 | 5 |
| | 27 | | 5 | 4 | 1 |
| | 28 | | 2 | 1 | 7 |
| | 31 | | 3 | 1 | 6 |
| | 32 | | | 2 | 8 |
| | 33 | | 7 | 1 | 2 |
| | 34 | | | 2 | 8 |
| | 37 | | | 7 | 3 |
| | 38* | | 8 | | 2 |
| | 40 | | | 4 | 6 |
| | 41* | | 6 | | 4 |
| | 42 | | 3 | 2 | 5 |
| | 58 | | 6 | 3 | 1 |
| 14 | 17* | | 3 | | 7 |
| | 24 | | | 3 | 7 |
| | 44 | | | 3 | 7 |
| | 48* | | 1 | | 9 |
| | 49 | | | 1 | 9 |
| | 50 | | | 7 | 3 |
| | 51 | | | 3 | 7 |
| | 52 | | | 1 | 9 |
| | 57 | | | 5 | 5 |
| | 59* | | 6 | | 4 |
| | 60 | | | 4 | 6 |
| | 61 | | | 2 | 8 |
| 17 | 1 | | 1 | 1 | 8 |
| | 2 | | | 8 | 2 |
| | 3 | | | 2 | 8 |
| | 6 | | | 1 | 9 |
| | 7 | | | 2 | 8 |
| | 8 | | | 2 | 8 |
| | 10 | | | 1 | 9 |
| | 13 | | 2 | 1 | 7 |
| | 15 | | | 7 | 3 |
| | 23 | | | 1 | 9 |
| | 53 | | | 9 | 1 |
| | 54 | | | 2 | 8 |
| | 55* | 9 | | | 1 |
| | 56 | | | 1 | 9 |

*Subjects who varied to non-adjacent steps in the hypothesized movement pattern developmental sequence.

Head and Trunk Movement Patterns: 1-Pelvis Leading; 2-Lateral Roll; 3-Roll-Off; 4-Come to Sit.

Table 22

Subjects Demonstrating Movement Pattern Variability in the Lower Extremities (n = 20 subjects in each age group, each performing 10 trials)

| Age Group (Years) | Subject Number | Movement Pattern | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| | | Number of Trials | | | |
| 11 | 21 | 1 | 4 | 3 | 2 |
| | 25 | | 4 | 6 | |
| | 26 | | 5 | 2 | 3 |
| | 27 | | 8 | 2 | |
| | 28 | 3 | 3 | 4 | |
| | 29* | | 2 | | 8 |
| | 30 | | 9 | 1 | |
| | 31 | | 3 | 7 | |
| | 32 | | 2 | 5 | 3 |
| | 33 | 2 | 4 | 4 | |
| | 34 | 4 | 1 | 1 | 4 |
| | 35 | | 4 | 6 | |
| | 36 | 1 | 7 | 2 | |
| | 37 | 2 | 6 | 2 | |
| | 38 | 2 | 3 | 5 | |
| | 39 | 4 | 4 | 2 | |
| | 40 | | 2 | 8 | |
| | 41 | | 3 | 2 | 5 |
| | 42 | 2 | 6 | 2 | |
| | 58 | | 9 | 1 | |
| 14 | 14 | 4 | 2 | 3 | 1 |
| | 16* | 1 | | 9 | |
| | 17 | 5 | 3 | 2 | |
| | 20* | 6 | | 4 | |
| | 22 | 2 | 1 | 3 | 4 |
| | 24 | 6 | 4 | | |
| | 43 | 1 | 1 | 4 | 4 |
| | 45 | 3 | 2 | 1 | 4 |
| | 46 | 7 | 1 | 2 | |
| | 47* | | 2 | | 8 |
| | 48 | 4 | 4 | 1 | 1 |
| | 49 | | 2 | 8 | |
| | 51 | 1 | 7 | 2 | |
| | 52 | 3 | 1 | 2 | 4 |
| | 57 | 8 | 2 | | |
| | 59 | 1 | 4 | 5 | |
| | 60 | 3 | 6 | 1 | |
| | 61 | | 4 | 5 | 1 |

(Continued)

Table 22 (Continued)

Subjects Demonstrating Movement Pattern Variability in the Lower Extremities (n = 20 subjects in each age group, each performing 10 trials)

| Age Group (Years) | Subject Number | Movement Pattern | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| | | Number of Trials | | | |
| 17 | 2 | | 4 | 6 | |
| | 3 | 5 | 5 | | |
| | 4 | | 9 | 1 | |
| | 6 | | 2 | 1 | 7 |
| | 7 | | 3 | 7 | |
| | 8 | | 2 | 8 | |
| | 9 | | 9 | 1 | |
| | 10 | | 3 | 7 | |
| | 11 | | 3 | 7 | |
| | 12* | 1 | | 5 | 4 |
| | 13 | 3 | 2 | 3 | 2 |
| | 15 | 4 | 1 | 5 | |
| | 19 | 7 | 3 | | |
| | 53 | | 7 | 3 | |
| | 54 | 4 | 6 | | |
| | 56 | | 6 | 3 | 1 |

*Subjects who varied to non-adjacent steps in the hypothesized movement pattern developmental sequence.

Lower Extremity Movement Patterns: 1-Step-Off; 2-Asynchronous With Leg Extension; 3-Asynchronous; 4-Synchronous.

Appendix J

Publishable Article

# Age-Related Differences in the Movement Patterns of Adolescents 11, 14, and 17 Years of Age Rising to Standing From Supine on a Bed

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Ann F. VanSant

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This study was completed in partial fulfillment of the requirements for Mrs. McCoy's Master of Science Degree in Physical Therapy at the Medical College of Virginia Campus/Virginia Commonwealth University.

ABSTRACT

Getting out of bed is an activity physical therapists commonly teach patients. This study's purposes were to determine: 1) if there are age-related differences in movement patterns (MPs) adolescents use to rise from a bed and 2) the most common MP combinations used to perform this task.

Sixty 11-, 14-, or 17-year-olds, were videotaped during 10 trials of rising. MPs of four body regions were classified using a set of descriptive categories for each region. Each MP's incidence and the most common MP combinations were determined for each age group.

Age-related differences in MPs used to rise were present in each region. The three MP combinations commonly observed in 11-year-olds, two in 14-year-olds, and one in 17-year-olds were described. One of these combinations was common across all age groups.

MPs used by adolescents when getting out of bed differ with age. Therapists can select age-appropriate MPs when teaching patients this activity.

## INTRODUCTION

Getting out of bed is an activity performed by most individuals at least once a day. Physical therapists frequently evaluate the ability of persons with motor impairments to perform this activity. When evaluating patients, clinicians are interested in both if patients can perform an activity and the movement patterns used. This information is used to identify functional impairments, establish realistic treatment objectives, and plan appropriate treatment activities. Therapists need to be aware of the various movement patterns adolescents use to get out of bed. This would allow clinicians to select from a greater variety of movement patterns when teaching patients this activity.

The main purpose of this research was to determine if there were age-related differences in the movement patterns used to come to standing from supine lying on a bed. An additional purpose was to describe the most common movement patterns used by adolescents to get out of bed.

## BACKGROUND

Adolescence is an important transitional period between childhood and adulthood (1). Several researchers (2-4) have documented quantitative changes in motor abilities occurring during the second decade of life. These changes were observed in broad jumping or throwing distance, running speed, or the number of push-ups completed. Few researchers have examined developmental changes in the movement patterns used to perform a task during adolescence. Longitudinal studies of movement pattern development in adolescents have been limited to activities such as throwing (5,6) and hopping

(7,8). The movement patterns used in these activities underwent developmental changes during the second decade.

Physical therapists frequently teach adolescents with motor impairments to roll from supine to prone, to get out of bed, and to stand from a seated position on a chair or a supine position on the floor. As part of a growing body of research examining age-related differences in the movement patterns used to perform such tasks, Boucher (9) studied adolescents performing the task of rolling from supine to prone. The movement patterns used to roll varied with age across the teen years.

Sarnacki (10) recently described movement patterns used by healthy adults to get out of bed. Thirty-five young adults were filmed during 10 trials of coming to standing from supine on a bed. The movements observed in each of four body regions were described. These regions were the "Far" Upper Extremity (FUE), "Near" Upper Extremity (NUE), Head and Trunk (HT), and Lower Extremities (LEs). Descriptive categories were formed to summarize the movement patterns of each body region. Based upon the nature of the subjects' movement pattern variability, a developmental sequence of movement patterns was hypothesized for each body region (Tables 1-4).

The present study was conducted to determine whether the movement patterns used to get out of bed vary with age in the order hypothesized by Sarnacki (10). In order for the proposed developmental order to receive support, younger subjects would have to demonstrate, with a greater frequency than older subjects, those movement patterns hypothesized to predominate earlier in the lifespan. Similarly, older subjects would be expected to demonstrate,

with a greater frequency than younger subjects, those movement patterns hypothesized to predominate later in the lifespan.

## METHODS

### Subjects

Sixty non-disabled adolescents participated in this study, 20 from each of three groups: 11 years, 14 years, and 17 years. The mean age, age range, standard deviation, and number of males and females are reported for each age group in Table 5. Subjects were recruited from schools and church groups in the Richmond, Virginia metropolitan area. Informed consent was obtained from parents or guardians prior to data collection and from each subject at the time of data collection. Individuals were excluded from the study if they reported any condition that potentially interfered with their ability to get out of bed, such as an orthopedic or neurologic disorder.

### Data Collection

Equipment. One video camera, connected to a power supply and video cassette recorder (VCR), and one video camcorder were used to record the movements of subjects while getting out of bed. Each camera was mounted on a tripod and was equipped with an automatic focus, a power zoom lens, and an electronic view finder. The bed was a standard twin size bed measuring approximately 1.88 m long, 0.96 m wide, and 0.51 m high.

Layout of data collection site. One camera was positioned facing one side of the bed, with the optical axis of the lens perpendicular to the length of the bed. The other camera was positioned facing the foot of the bed with the optical axis of the lens perpendicular to the width of the bed. The cameras were located approximately 7.2 m and

6.2 m from the center of the bed for the side and foot view cameras respectively. The distance from the floor to the center of the camera lens was approximately 0.87 m for the side view camera and approximately 0.93 m for the foot view camera. A board with two sets of numbers was placed within view of both cameras to identify subject and trial numbers.

Procedures. JOM and assistants collected the data. The purposes and procedures of the study were first explained to the subject. Each subject was asked to remove shoes and socks and to lie supine in the center of the bed with arms beside the body. Two commands, "ready" and "go," were given. On the command "ready," video-recording was started, and on the command "go," the subject rose as rapidly as possible and stood until asked to lie back down. All subjects turned to their left side while rising. The direction of rising was determined by constraints in the environment of the first filming site. At that site, cameras could only be located to obtain a left side and foot view. The subjects were asked to rise quickly to minimize time for thinking about the form of the movements used during the activity (11). Ten consecutive trials were videotaped.

Data Reduction

Movement pattern classification. Videotapes were analyzed using a television monitor and video cassette player/recorder (VCR) with stop action, slow motion playback capabilities. The movements used by each subject to get out of bed were categorized by JOM for each body region using the descriptions in Tables 1-4. Beginning with the upper extremity closest to the side view camera, the first trial of all subjects was reviewed, followed by the second trial of all subjects

etc., until the NUE movements of all subjects had been classified. Any movements that could not be classified were described in writing. This procedure was then repeated for each of the other three regions.

Reliability. After data reduction was completed, inter-rater reliability classifying movement patterns was examined for each body region. Data from 60 randomly selected trials were classified by AFV. These categorizations were compared to JOM's categorizations. If less than 85% exact agreement was obtained, discrepancies were identified, and the descriptive categories were clarified. JOM then repeated the data reduction process for that body region. This process was repeated until at least 85% exact agreement was obtained for each body region. Kappa statistics (12) were then calculated to estimate inter-rater reliability.

Data Analysis

Age-related movement pattern differences and hypothesized developmental sequences. For each body region, the incidence of each movement pattern was determined across all trials for each age group. To illustrate age group differences, the percent occurrence of each movement pattern was graphed with respect to age group for each body region. The percent occurrences were compared to determine if younger subjects demonstrated, with a greater frequency than older subjects, those movement patterns hypothesized to predominate earlier in the lifespan. Similarly, the percent occurrences were compared to determine if older subjects demonstrated, with a greater frequency than younger subjects, those movement patterns hypothesized to predominate later in the lifespan.

Most common form of rising. The combination of FUE, NUE, HT, and LE movement patterns demonstrated during each trial of rising was determined. The percent occurrence of each combination of movement patterns was determined across all subjects and trials for each age group. The most common combination of FUE, NUE, HT, and LE patterns was then identified for each age group.

## RESULTS

### Reliability

The percent exact agreement achieved between AFV and JOM classifying the movement patterns from 60 randomly selected trials was 95%, 85%, 90%, and 86.5% for the FUE, NUE, HT, and LEs, respectively. The values of Kappa for the FUE, NUE, HT, and LEs were 0.91, 0.76, 0.89, and 0.82, respectively

### Movement Pattern Classification

The movement pattern descriptions (Tables 1-4) developed for young adults (10) described all but one of the movements observed in adolescents. The new NUE pattern was called Lift and Reach (Table 2).

Although no new movement patterns were observed in the HT region, three of the four original HT categories (10) were rewritten to better describe the movement patterns and to make them more generalizable. These descriptions appear in their revised form in Table 3.

After the HT movement pattern descriptions were revised, data from this study were reclassified for the HT region. Inter-rater reliability tests were repeated using 100 randomly selected trials from the data of adolescents, young adults (10), and middle-aged adults (C. D. Ford-Smith, unpublished data, August, 1988). These data sets were used to assess the generalizability of the revised HT

categories across a wider age range of subjects. Percent exact agreement between AFV and JOM was 88%. The value of Kappa was 0.76.

Age-related Movement Pattern Differences

The observed incidence of each movement pattern for the FUE, NUE, HT, and LEs, respectively, is included in Tables 1-4. Figures 1-4, respectively, graph the observed incidence of FUE, NUE, HT, and LE movement patterns across age groups. The relationship of each movement pattern to age is analyzed below in the order in which Sarnacki (10) hypothesized the patterns would predominate.

Far upper extremity. Lateral Lift and Push, step 1 of the proposed developmental sequence, was the least common movement pattern in all three age groups. This pattern occurred at a very low frequency in 11-year-olds and was not observed in 14- or 17-year-olds. Push was proposed as the second step of the developmental sequence. Although it was never seen on more than 20% of an age group's trials, the pattern was seen at its highest frequency in 17-year-olds. Double Push, the third step of the sequence occurred commonly in all three age groups. A peak frequency was observed in 14-year-olds. Lift and Push, the fourth step, varied in frequency across age groups, being least common in 14-year-olds. Lift or Lift and Reach, the final step, occurred infrequently in 11- and 17-year-olds and was not observed in 14-year-olds.

Near upper extremity. Lateral Lift and Push, the first step of the proposed sequence, was seen with greatest frequency in 11-year-olds. The frequency was approximately the same in 14- and 17-year-olds. Grasp and Push, hypothesized as the second step in the developmental sequence, was the predominant pattern observed in 14-

year-olds. Push, the third step of the hypothesized sequence, was the most common movement pattern among 11- and 17-year-olds. Lift and Reach was a new pattern not a part of Sarnacki's sequence. This pattern occurred infrequently among 11- and 17-year-olds and was not observed among 14-year-olds.

Head and trunk. Pelvis Leading, hypothesized as the first step in the head and trunk developmental sequence, was observed infrequently in 11- and 17-year-olds. This pattern was not observed in 14-year-olds. The second step in the proposed sequence, Lateral Roll, was observed in more than one third of the trials of subjects 11 years of age. This pattern was seen in only 10% of the trials of subjects 14 years of age and infrequently in the oldest subjects. Roll-Off, the third step of the proposed sequence, occurred at a similar frequency in 11- and 14-year-olds. This pattern reached its peak frequency in 17-year-olds. Come to Sit, hypothesized as the last pattern to predominate, was the most common pattern for all three age groups. The pattern was seen at its lowest frequency in 11-year-olds, reached its peak frequency among 14-year-olds, and was slightly less common among 17-year-olds.

Lower extremities. Step-Off, hypothesized as the first step in the lower extremity developmental sequence, was the most common movement pattern demonstrated by 14-year-olds. The second step in the proposed sequence, Asynchronous With Leg Extension was the most common movement pattern demonstrated by 11- and 17-year-olds. Asynchronous, hypothesized as the third step in the sequence, differed little in frequency across the three age groups. This pattern was observed in approximately one quarter of the trials of each group. Synchronous,

the fourth step in the proposed sequence, also differed little in frequency across the adolescent age groups. This pattern varied between approximately 5% and 15% of the trials of the three groups.

Most Common Form of Rising

A total of 89 different movement pattern combinations were observed across the three age groups. Sixty-seven different combinations were observed in 11-year-olds, compared to 40 in 14-year-olds and 44 in 17-year-olds. No subject demonstrated the same movement pattern combination across all 10 trials. The three most common movement pattern combinations for each age group accounted for approximately one third of the trials of the 14- and 17-year-olds but only approximately one fifth of the trials of the 11-year-olds.

For subjects 11 years of age, three common movement pattern combinations were observed. These combinations each occurred across approximately 6% of the 11-year-olds' trials and differed from each other only in NUE or HT action (Figures 5, 6, and 7).

For subjects 14 years of age, there were two movement pattern combinations which occurred with almost equal frequency. Each was observed in approximately 12% of the trials. These two combinations differed from each other only in LE action (Figures 5 and 8).

For subjects 17 years of age, there was a single most common movement pattern combination (Figure 5), which was demonstrated across approximately 15% of the trials. This combination was one of the most common forms of rising demonstrated by 11- and 14-year-olds.

## DISCUSSION

### Movement Pattern Classification

With the exception of the one new pattern observed in the NUE, the movement patterns identified in the young adult study (10)

described the movements demonstrated by these adolescents. Although patterns which predominate early or quite later in a lifespan developmental sequence may not be observed when a sample of young adults is used to identify the movement patterns for a task (11), Sarnacki's study of young adults getting out of bed (10) proved a useful first step prior to studying adolescents.

Age-related Movement Pattern Differences and Hypothesized Developmental Sequences

Far upper extremity. There was little difference between the three age groups in the frequency of occurrence of four of the five FUE movement patterns. The marked drop in the incidence of the Double Push pattern between 14- and 17-year-olds was the most notable age-related difference. Because the age-related differences were limited, determining if the movement patterns were becoming more or less common in the order predicted by Sarnacki (10) was not possible. The adolescent data were therefore compared to the data obtained by Sarnacki (10) in her study of young adults.

Sarnacki (10) hypothesized that the movement patterns would become predominant in the following order: Lateral Lift and Push, Push, Double Push, Lift and Push, and Lift or Lift and Reach. The low incidence of the Lateral Lift and Push pattern among adolescents as compared to young adults (10) suggests that this pattern may be a later movement pattern to become predominant. This would not support Sarnacki's hypothesis that Lateral Lift and Push was the earliest pattern to predominate.

Push, the most common FUE movement pattern among young adults, occurred infrequently among adolescents. The Double Push pattern, which was predominant in adolescents, was less common young adults. In contrast to Sarnacki's prediction, the Double Push pattern most likely predominates before the Push pattern.

Lift and Push was observed in fewer of the trials of 14-year-olds and young adults than of 11- and 17-year-olds, always occurring less than 15%. Because of this low, variable incidence, predicting whether Lift and Push is an earlier or later predominating pattern was not possible based upon observed age-related differences. Further cross-sectional study of children and middle-aged adults could help clarify when this pattern would likely predominate.

Lift or Lift and Reach was observed at low frequencies in both young adults (10) and adolescents. Sarnacki (10) hypothesized this pattern as the latest pattern to become predominant because of its similarity to Symmetrical Reach, hypothesized as the most advanced UE pattern used to rise to standing from supine on the floor (13). Because of the low incidence of this movement pattern throughout adolescence and young adulthood, however, this movement pattern may not represent a developmental step. Further cross-sectional study of other age groups could clarify whether the Lift or Lift and Reach pattern is a step within the developmental sequence.

Based upon the movement pattern frequencies observed in this study and those reported by Sarnacki (10), the likely order of predominance of the Lateral Lift and Push, Push, and Double Push patterns appears to be Double Push, Push, and Lateral Lift and Push, successively. To determine whether the Lift and Push pattern likely

predominates before Double Push or after Lateral Lift and Push, the nature of the subjects' movement pattern variability was examined. Using this method (10), Lift and Push likely predominates before Double Push.

Therefore, the hypothesized sequence was not supported. As a result of the present study, the developmental sequence for the FUE is hypothesized to be in successive order for the period leading up to adolescence and into the middle adult years: Lift and Push, Double Push, Push, and Lateral Lift and Push.

Near upper extremity. Sarnacki (10) hypothesized that the NUE movement patterns would become predominant in the following order: Lateral Lift and Push, Grasp and Push, and Push. Lateral Lift and Push was supported as an earlier pattern to predominate because of its sharply decreased incidence in older age groups as compared to 11-year-olds. The limited age-related differences observed among adolescents in the frequency of occurrence of the Grasp and Push and Push patterns did not allow identification of the likely developmental sequence ordering without again referring to Sarnacki's (10) data.

Because Grasp and Push showed an increased frequency in young adults as compared to 17-year-olds and because Push showed a decreased frequency in young adults as compared to 17-year-olds, the NUE sequence appears to have been misordered. Push would likely predominate before Grasp and Push.

Since Lift and Reach was not observed in young adults and was observed at a very small frequency in adolescents, this pattern may not represent a developmental step. Further cross-sectional study of

other age groups, such as children, middle-aged adults, or the elderly, could determine how prevalent this movement pattern is in other age groups.

Based upon the results of this study and Sarnacki's (10) reported frequencies, the hypothesized sequence was not supported. The developmental sequence for the NUE for the period leading up to adolescence and into the middle adult years is proposed to be in successive order: Lateral Lift and Push, Push, and Grasp and Push.

Head and trunk. Pelvis Leading, Lateral Roll, Roll-Off, and Come to Sit is the successive developmental order hypothesized by Sarnacki (10) for the HT. Pelvis Leading, observed infrequently among adolescents, was also observed infrequently among young adults. Therefore, there does not yet appear to be a relationship between this pattern and age. Pelvis Leading was hypothesized by Sarnacki as the first step in the sequence (Table 3) because of its similarity to an early rolling pattern in infants (14). Further cross-sectional study of a younger age group could clarify whether this pattern is likely to be more common prior to adolescence.

The Lateral Roll pattern was more common in younger adolescents than in older adolescents and young adults. This pattern received support as an early step in the hypothesized developmental sequence.

Roll-Off, which appeared to be increasing in frequency with increasing age across adolescence, was the predominant HT pattern in young adults. Come to Sit, the predominant HT pattern of adolescents, demonstrated a greatly decreased frequency among young adults. Come to Sit, therefore, appears to be an earlier step than Roll-Off. This indicates that the sequence proposed by Sarnacki (1985) is probably misordered.

Based on the age-related movement pattern differences observed, Sarnacki's (10) hypothesized sequence was not supported. The order of development of the HT movement patterns is hypothesized to be for the period leading up to adolescence and into the middle adult years: Lateral Roll, Come to Sit, and Roll-Off.

Lower extremities. Sarnacki (10) hypothesized that the developmental sequence for the LE movement patterns was Step-Off, Asynchronous With Leg Extension, Asynchronous, and Synchronous. Step-Off was not supported as the earliest pattern to predominate because this pattern was predominant in 14-year-olds but not in younger or older adolescents. Step-Off, therefore, is not likely the earliest pattern to predominate as Sarnacki (10) hypothesized.

Asynchronous With Leg Extension was the most common movement pattern in 11- and 17-year-olds. Among young adults (10), this movement pattern was less common than in 17-year-olds. Asynchronous With Leg Extension may, therefore, represent the earliest pattern to predominate in the LE sequence. This pattern may then again become predominant after the Step-Off pattern, as was observed in this study.

Because the Asynchronous and Synchronous patterns varied little in frequency among adolescents, Sarnacki's (10) data of young adults were used to hypothesize the position of these patterns in the developmental sequence. Asynchronous, which was never common in adolescents, was the most common LE movement pattern in young adults. This trend supports the Asynchronous pattern as a later step to predominate in the sequence.

Synchronous was observed in less than 15% of the trials of adolescents and young adults. Because of this low incidence and the limited age-related differences, whether this movement pattern is a

later predominating pattern would require further cross-sectional study of an older age group of subjects, such as middle-aged adults. However, Sarnacki (10) hypothesized Synchronous as the last step in the sequence because of its similarity to the Symmetrical Squat pattern, hypothesized to be the most advanced LE pattern used to rise to standing from the floor (13).

Based upon the observed incidence of movement patterns in this study and in Sarnacki's study of young adults (10), it appears that the hypothesized developmental sequence for the LEs was correctly ordered but did not account for the finding that Asynchronous With Leg Extension might predominate just prior to when the four step sequence is observed. The developmental sequence for the LEs is proposed to be in successive order for the period leading up to adolescence and into the middle adult years: Asynchronous With Leg Extension, Step-Off, Asynchronous With Leg Extension, Asynchronous, and Synchronous.

Most Common Form of Rising

There was a large amount of inter-individual and intra-individual variability in the movement pattern combinations used by adolescents when getting out of bed. This indicates that adolescents have available to them a number of different movement pattern combinations to use when getting out of bed.

One of the three combinations demonstrated commonly by 11-year-olds was the same as one of the two combinations demonstrated commonly by 14-year-olds and was the same as the most common combination demonstrated by 17-year-olds. The similarities in common movement pattern combinations for each age group suggest that the age intervals chosen for this study may have been too small. Greater age

differences in the most common movement pattern combinations may have been observed if larger age intervals, perhaps four or five years, had been selected. Greater age differences in the incidences of the most common combinations may also have been observed if a larger number of adolescents had been studied. Because there were only twenty subjects in each age group, the movement patterns demonstrated by just one or two individuals could have significantly altered the observed incidence of various movement pattern combinations.

The most common movement pattern combinations observed in adolescents differed from the one reported by Sarnacki in her study of young adults (10). This is an additional indicator that there are age-related differences in the movement patterns used to get out of bed.

Implications for Clinical Practice

Physical therapists frequently treat patients who are unable to get out of bed. Knowledge of the wide variety of movement patterns used to get out of bed should allow therapists to choose from a greater variety of patterns when teaching this activity. Knowing that there are age-related differences in the movement patterns used to get out of bed, therapists can select age-appropriate patterns to teach their adolescent or young adult patients.

The movement patterns used by patients may eventually be easily classified in a clinical setting. When working with patients, therapists can observe the movement patterns demonstrated by their patients from either side or foot views as was done in this study. Videotaping could also be used to provide supportive, objective documentation of patients' movement patterns.

## CONCLUSIONS

Descriptions of the movement patterns used by young adults getting out of bed describe most of the movement patterns used by adolescents. The one new NUE pattern that was observed in this study, Lift and Reach, did not demonstrate a clear relationship to age and may not represent a developmental step.

There are age-related differences in the movement patterns used by adolescents to rise to standing from supine on a bed. However, the movement patterns and movement pattern combinations demonstrated by adolescents when getting out of bed are quite variable.

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TABLE 1

Far Upper Extremity Movement Patterns and Percent Occurrences [a]

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1) Lateral Lift and Push: The upper extremity lifts or slides on the supporting surface toward the head of the bed. The entire upper extremity, or some part of it, is placed on the bed and pushes. The extremity extends until the hand is the only part of the upper extremity remaining on the bed. The hand lifts and the extremity may be used as a balance assist.

(1.5%, 0%, 0%)

2) Push: The entire upper extremity, or some part of it, pushes into the bed. The upper extremity extends until the hand or elbow is the only part of the upper extremity remaining on the bed. The hand or elbow lifts and the extremity may be used as a balance assist.

(16.5%, 16.5%, 20.0%)

3) Double Push: The entire upper extremity lifts toward the head of the bed and pushes or pushes into the bed without lifting. The extremity extends until the hand or elbow is the only part of the upper extremity remaining on the bed. The hand or elbow lifts, and the hand is placed on the bed, usually near the edge, and pushes. The hand lifts and the extremity may be used as a balance assist.

(72.0%, 83.0%, 63.5%)

4) Lift and Push: The upper extremity lifts off the bed and may reach across the body. The hand is placed on the bed on the same side of the body at some point between the starting position and the edge of the bed and pushes. The hand lifts and the extremity may be used as a balance assist.

(8.0%, 0.5%, 13.0%)

5) Lift or Lift and Reach: The upper extremity lifts off the bed and may reach across the body. The extremity may be used as a balance assist.

(2.0%, 0.0%, 3.5%)

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[a] Movement patterns from Sarnacki (10). A lettering system was used in Sarnacki's study to identify these movement patterns. The movement patterns are listed here in the order in which Sarnacki proposed the patterns would develop. Pattern 1 was expected to predominate prior to pattern 2. Pattern 2 was expected to predominate prior to pattern 3, and so forth. The numbers in parentheses represent the observed percent occurrence of each movement pattern for subjects 11, 14, and 17 years of age respectively.

TABLE 2

Near Upper Extremity Movement Patterns and Percent Occurrences[a]

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1) Lateral Lift and Push: The upper extremity lifts or slides on the supporting surface toward the head of the bed. The entire upper extremity, or some part of it, is placed on the bed and pushes until the extremity is in the extended or nearly extended position, and the hand is the only part of the extremity remaining on the bed. The hand lifts, and the extremity may be used as a balance assist.
(25.0%, 9.5%, 10.5%)

2) Grasp and Push: The upper extremity slides or lifts to position the hand to grasp the edge of the bed. The entire upper extremity, or some part of it, pushes down on the bed while the hand grips on the edge. The upper extremity lifts and may be used as a balance assist.
(36.5%, 48.5%, 42.0%)

3) Push: The entire upper extremity, or some part of it, pushes into the bed. The extremity lifts from the bed and may be used as a balance assist.
(38.0%, 42.0%, 47.0%)

4) Lift and Reach: The upper extremity is lifted off the bed without pushing. The extremity may be used to reach forward and/or as a balance assist.
(0.5%, 0%, 0.5%)

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[a]Movement patterns 1-3 are from Sarnacki (10). A lettering system was used in Sarnacki's study to identify these movement patterns. Patterns 1-3 are listed here in the order in which Sarnacki proposed the patterns would develop. Pattern 1 was expected to predominate prior to pattern 2. Pattern 2 was expected to predominate prior to pattern 3. Movement pattern 4 was a new movement pattern in this study. The numbers in parentheses represent the observed percent occurrence of each movement pattern for subjects 11, 14, and 17 years of age respectively.

TABLE 3

Revised Head and Trunk Movement Patterns and Percent Occurrences[a]

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1) Pelvis Leading: The lower trunk rotates to the side. At sidelying, the upper side of the pelvis drops to the bed, and the trunk lifts and turns toward side facing. The subject may be in a symmetrical sitting posture before standing.
(5.0%, 0%, 4.5%)

2) Lateral Roll: The head and trunk turn toward the side facing position with minimal flexion toward the foot of the bed. In the side facing position, one buttock is off the bed, and the shoulders and pelvis are aligned and displaced toward the head of the bed. When the buttocks come off the bed, the head and trunk may be displaced toward the head of the bed, or the subject may be in a symmetrical sitting posture.[b]
(34.5%, 10.0%, 1.5%)

3) Roll-Off: The head and trunk flex and turn toward side facing with the weight shifted to one buttock.[c] Just before both buttocks come off the bed, the head and trunk are displaced toward the head of the bed through lateral flexion and/or rotation.
(17.5%, 14.5%, 24.0%)

4) Come to Sit: The head and trunk flex symmetrically or flex and turn toward side facing by pivoting on one or both buttocks.[d] Just before both buttocks come off the bed, the trunk is in a symmetrical sitting posture, though it may be flexed forward.
(43.0%, 75.5%, 70.0%)

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[a]Movement patterns from Sarnacki (10). A lettering system was used in Sarnacki's study to identify these movement patterns. The movement patterns are listed here in the order in which Sarnacki proposed the patterns would develop. Pattern 1 was expected to predominate prior to pattern 2. Pattern 2 was expected to predominate prior to pattern 3, and so forth. The numbers in parentheses represent the observed percent occurrence of each movement pattern for subjects 11, 14, and 17 years of age respectively.

-Continued-

TABLE 3 (Continued)

Revised head and Trunk Movement Patterns and Percent Occurrences

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[b]The words underlined indicate a line change made in Sarnacki's (1985) original description of the Lateral Roll pattern which read: "Just before the buttock comes off the bed, the head and trunk are displaced toward the head of the bed through lateral flexion and/or rotation."

[c]The Roll-Off pattern was revised by eliminating the following sentence: "In the side-facing position, the pelvis may drop to a level position."

[d]The Come to Sit pattern was revised by eliminating the following sentence: "If the trunk pivots on one buttock, the pelvis may drop to a level position before standing."

TABLE 4

Lower Extremity Movement Patterns and Percent Occurrences[a]

1) Step-Off: The lower extremities are lifted asynchronously off the bed. The far extremity may push on the bed before lifting. The far extremity flexes toward the chest such that the thigh is above the near extremity thigh. The feet are usually placed on the floor asynchronously, and the near extremity may begin to extend before the far extremity foot is placed on the floor.
(10.5%, 32.5%, 17.0%)

2) Asynchronous With Leg Extension: The lower extremities are lifted asynchronously off the bed. The far lower extremity may push on the bed prior to lifting. The thighs remain parallel as they move across the bed. The far lower extremity may be extended as it moves across and over the edge of the bed. The far lower extremity foot is in front of the near lower extremity leg as the legs descend toward the floor. The feet are placed on the floor, and the lower extremities extend to the upright position.
(44.5%, 28.0%, 47.5%)

3) Asynchronous: The lower extremities are lifted asynchronously off the bed. The far lower extremity may push on the bed before lifting and is usually medially rotated. The thighs are parallel as they move across the bed, and the legs are parallel as they descend toward the floor. The feet are placed on the floor simultaneously, and the lower extremities extend to the upright position.
(32.5%, 26.0%, 28.5%)

4) Synchronous: The lower extremities are lifted or slid simultaneously off the bed. A brief push on the bed may proceed the lifting. The lower extremities move together over the edge of the bed. The feet are placed on the floor simultaneously. The lower extremities extend to the upright position.
(12.5%, 13.5%, 7.0%)

[a]Movement patterns from Sarnacki (10). A lettering system was used in Sarnacki's study to identify these movement patterns. The movement patterns are listed here in the order in which Sarnacki proposed the patterns would develop. Pattern 1 was expected to predominate prior to pattern 2. Pattern 2 was expected to predominate prior to pattern 3, and so forth. The numbers in parentheses represent the observed percent occurrence of each movement pattern for subjects 11, 14, and 17 years of age respectively.

TABLE 5

Sample Mean Age, Age Range, and Standard Deviation (N = 60)

| Age Group (yr) | Mean Age | Age Range | Standard Deviation |
|---|---|---|---|
| 11[a] | 11 yr 3.2 mo | 11 yr .5 mo to 11 yr 9.6 mo | 2.6 mo |
| 14[b] | 14 yr 5.8 mo | 14 yr .5 mo to 14 yr 11.0 mo | 3.4 mo |
| 17[c] | 17 yrs 6.4 mo | 17 yr 1.3 mo to 17 yr 11.9 mo | 3.0 mo |

[a] n = 20, 10 males and 10 females.

[b] n = 20, 11 males and 9 females.

[c] n = 20, 9 males and 11 females.

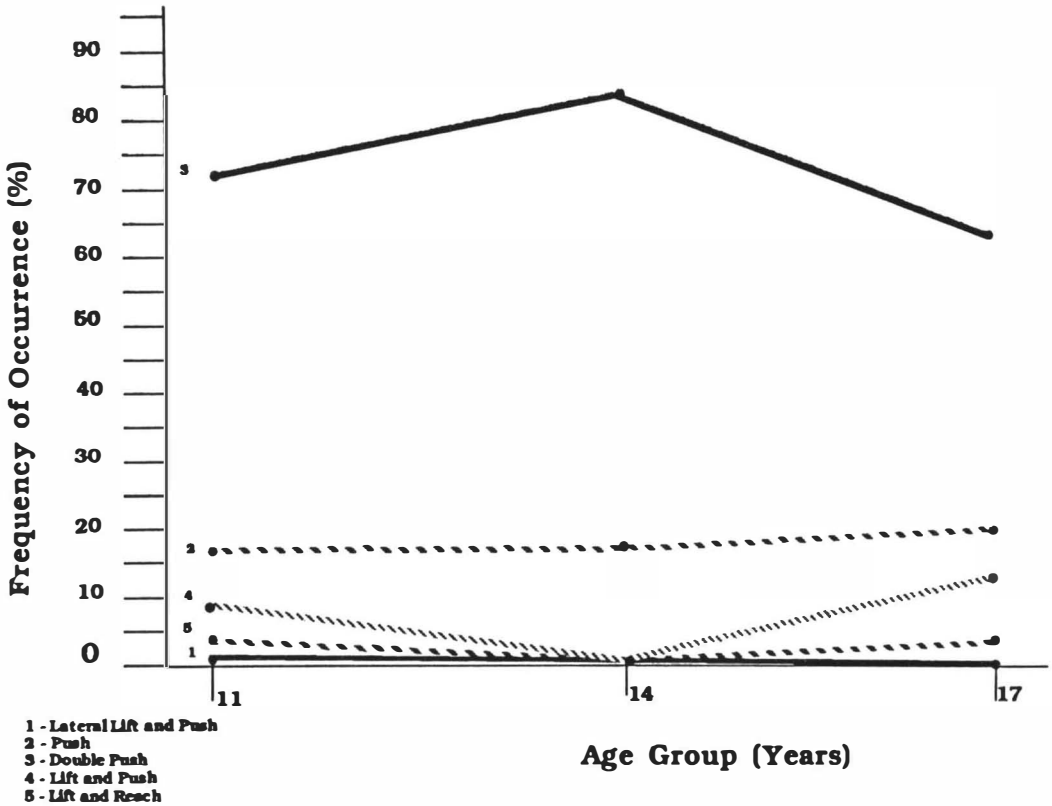


**Figure 1.** **Observed Frequency of Occurrence of Far (Right) Upper Extremity Movement Patterns.**

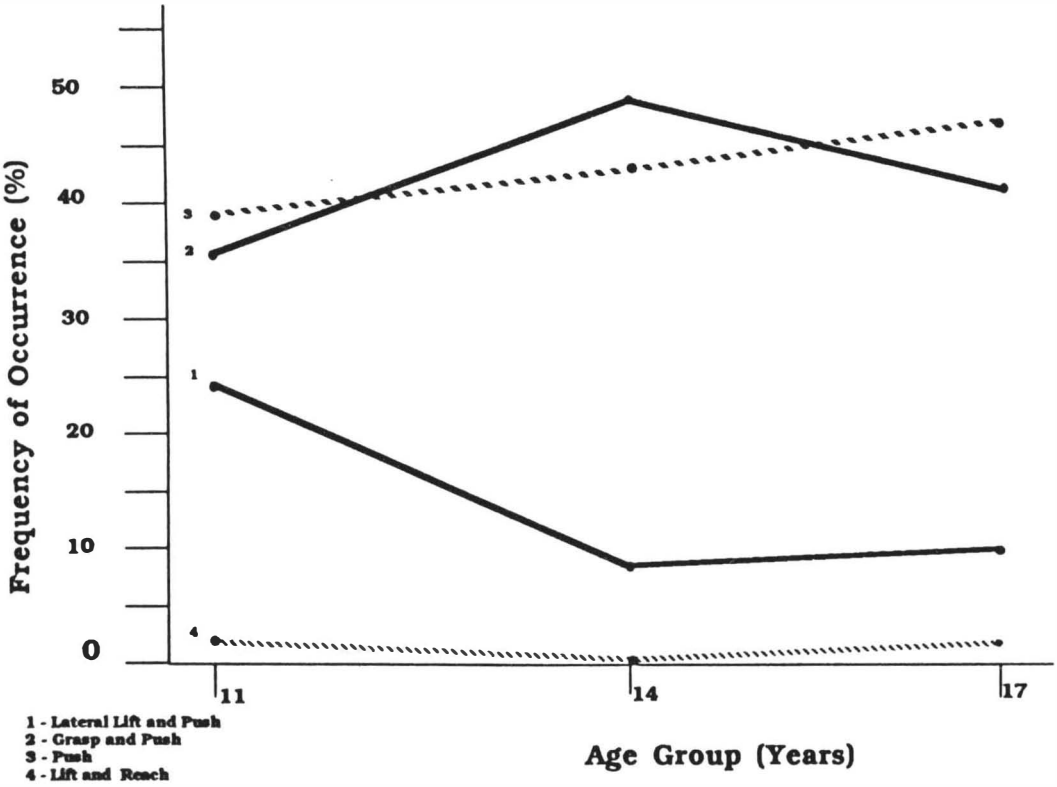


**Figure 2.** **Observed Frequency of Occurrence of Near (Left) Upper Extremity Movement Patterns.**

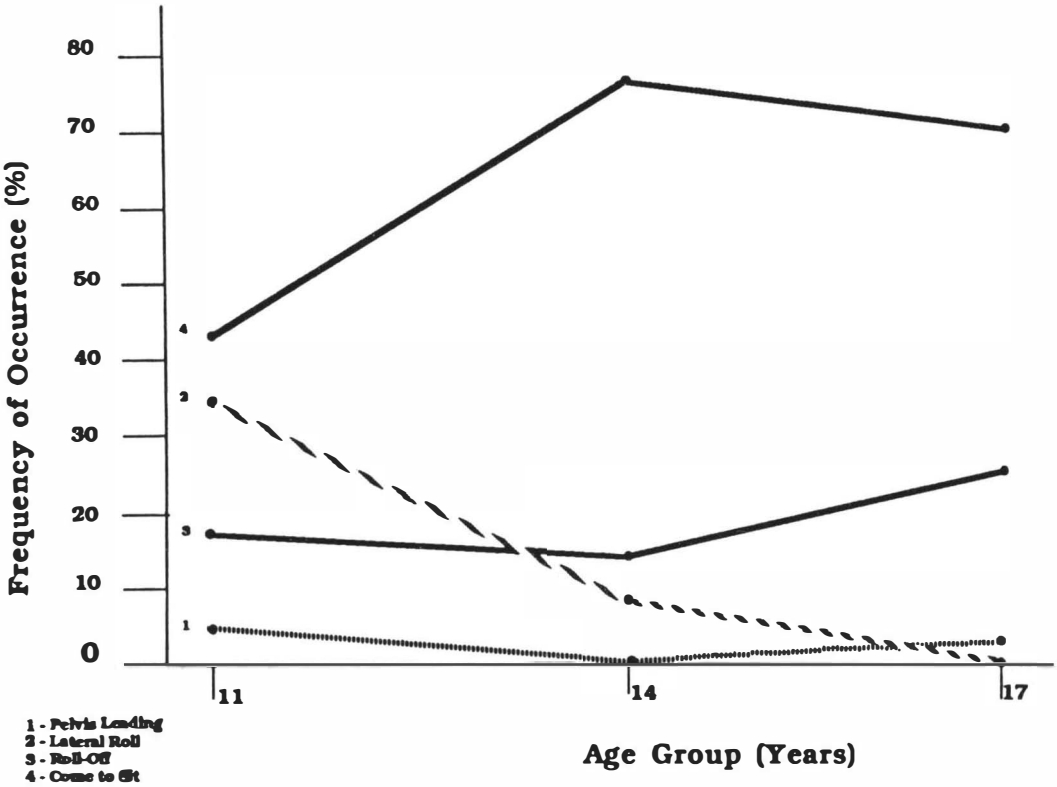


**Figure 3.** **Observed Frequency of Occurrence of Head - Trunk (HT) Movement Patterns.**

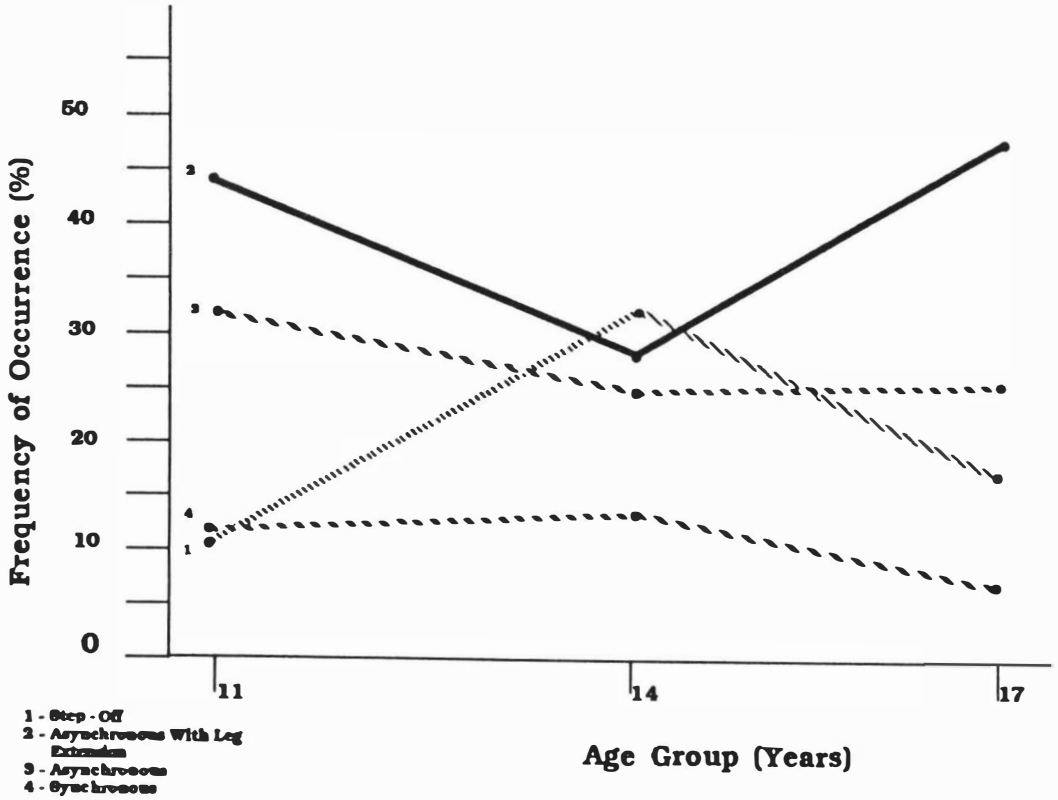


**Figure 4.** **Observed Frequency of Occurrence of Lower Extremity Movement Patterns.**

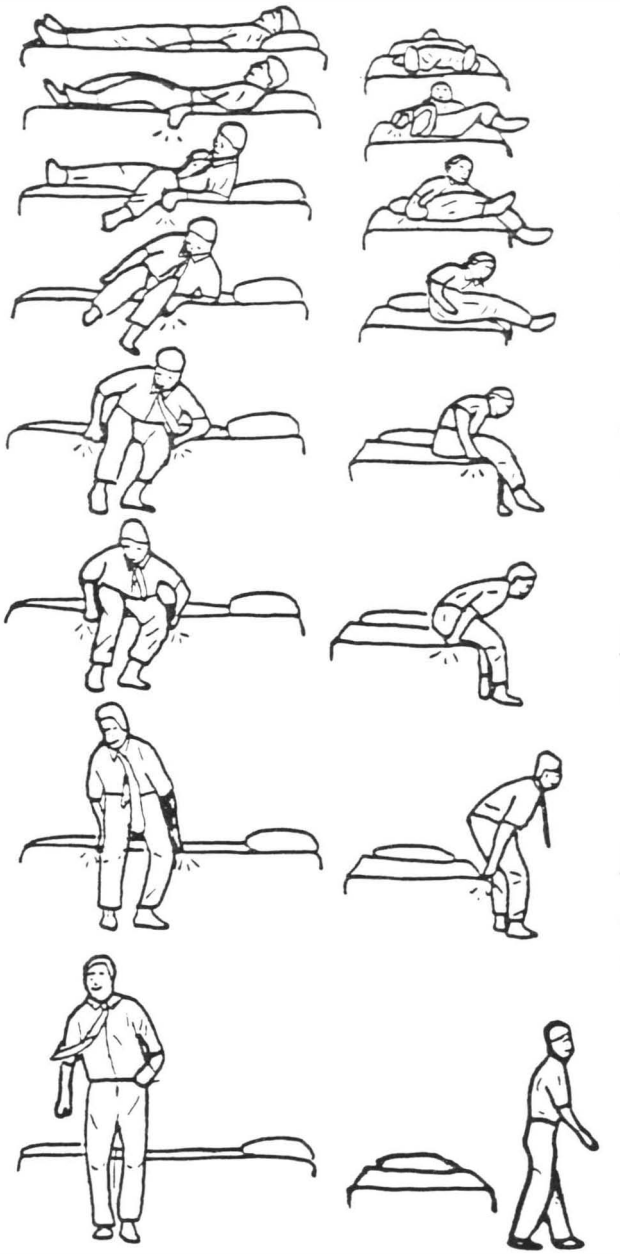


Figure 5. One of the Three Most Common Movement Pattern Combinations (MCMPC) Demonstrated by 11-Year-Olds, One of the Two MCMPC Demonstrated by 14-Year-Olds, and the MCMPC Demonstrated by 17-Year-Olds.

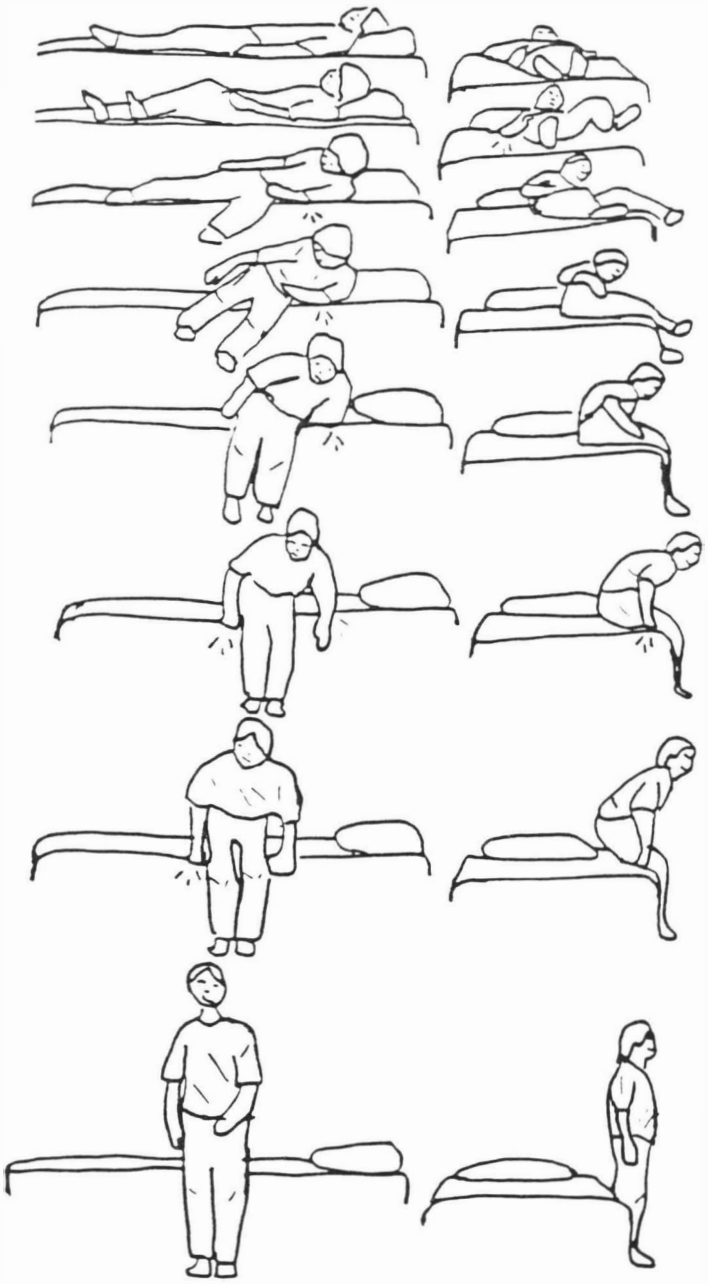


Figure 6. One of the Three Most Common Movement Pattern Combinations Demonstrated by 11-Year-Olds (a).

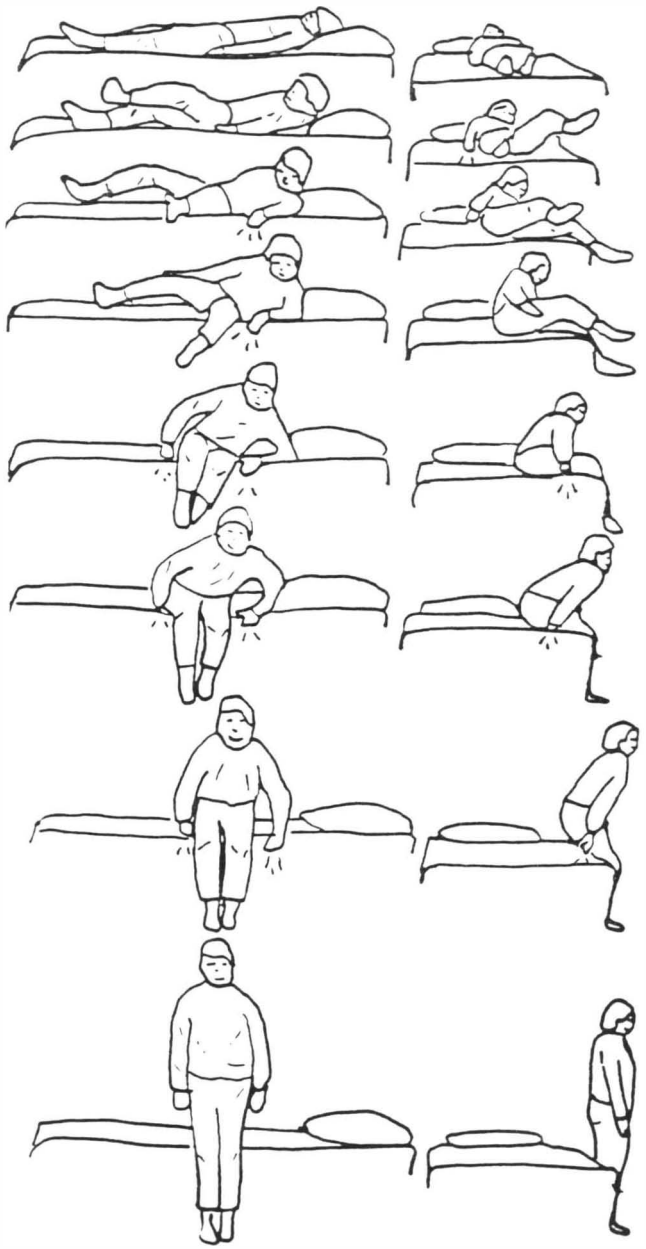


Figure 7. One of the Three Most Common Movement Pattern Combinations Demonstrated by 11-Year-Olds (b).

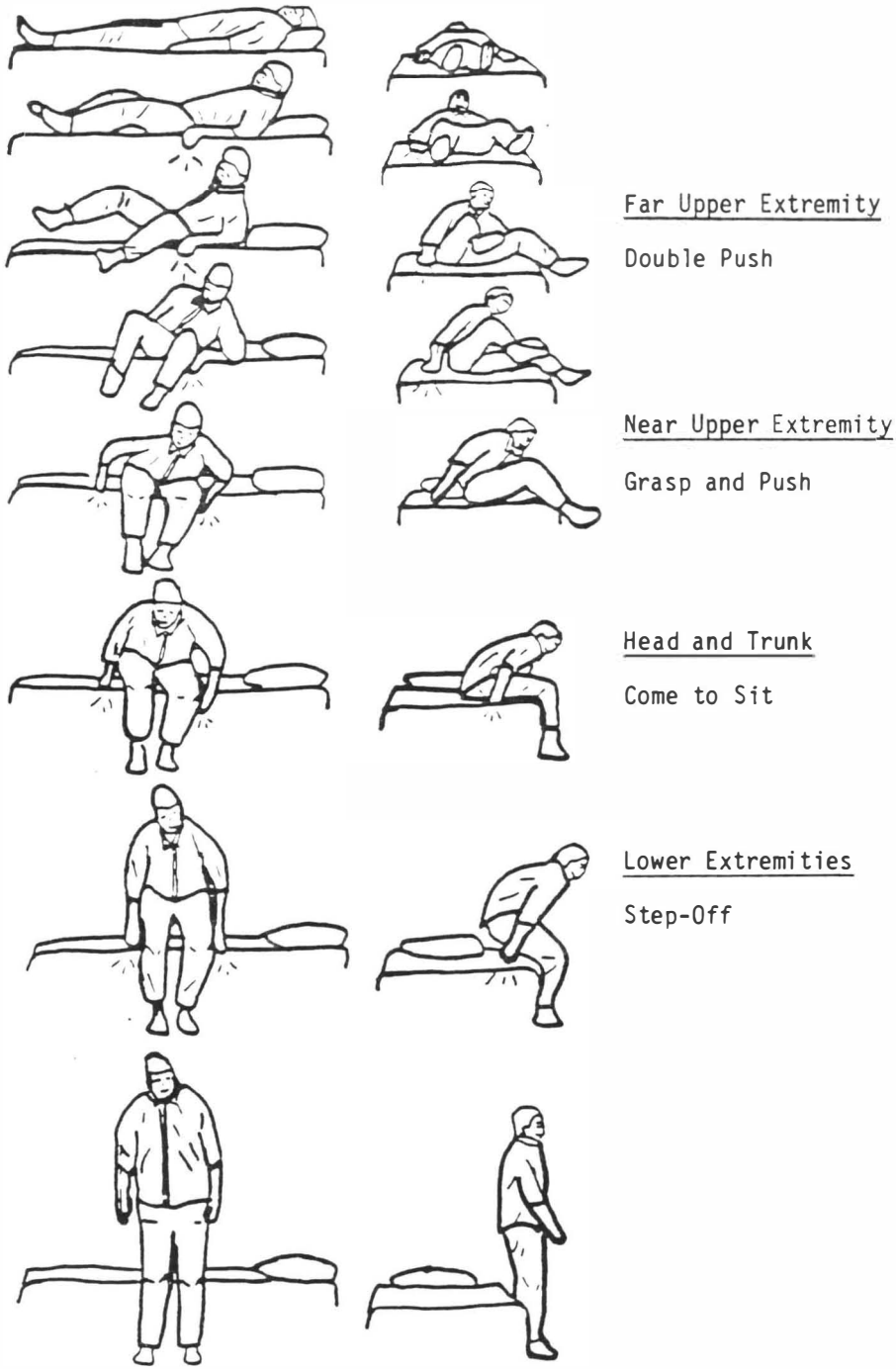


Figure 8. One of the Two Most Common Movement Pattern Combinations Demonstrated by 14-Year-Olds.

# Vita