# FATIGUE AFTER CLOSED HEAD INJURY

by

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B.Sc., University of Victoria, 1978
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A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of

DOCTOR OF PHILOSOPHY

in the Department of Psychology



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ABSTRACT

Closed head injuries are common occurrences in North America. Subsequent to a closed head injury (CHI), there are a number of symptoms which are commonly seen, one of which is fatigue. No studies were found which specifically address the issue of fatigue following CHI. Much remains unknown about this symptom, such as the percentage of individuals who experience fatigue as a problem after a CHI, the relationship between the degree of fatigue experienced and the severity of the injury, and the length of time that this problem persists following the injury. The present study explores and describes the problem of fatigue in a population of individuals following a CHI.

In this study, 28 individuals who had experienced a CHI (14 with minor injuries and 14 with severe injuries) were each paired with a control subject who had not had a CHI and who was matched to the CHI subject in terms of age, sex, and personality characteristics. All subjects were asked to complete two brief questionnaires, two computerized tasks, and two self-report measures. All 28 subject pairs completed the first four measures and 22 of the pairs completed and returned the last two. The results showed a highly significant difference between the CHI and control groups on all measures. There were no differences between the CHI subgroups (minor and severe) on any of the measures, nor was there a relationship found between length of post traumatic amnesia or length of time post-injury and any of the measures. There was an interaction between the results on the measure of depression and four of the other five variables Further analysis demonstrated differences between the CHI and control groups on all measures after the depression scores were taken into account.

These results indicate that fatigue is a serious, long-lasting problem for this groups of individuals who have experienced a CHI. Suggestions for future research and for treatment are discussed.

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# DEDICATION

This study is dedicated to all those who gave so freely of their time, their knowledge, and their support, without which this work would not have been possible. Particular thanks must go to my husband and to the staff and patients of the Gorge Road Hospital Head Injury Rehabilitation Program.

# CHAPTER ONE

Head injuries happen very frequently in North America. They happen on playgrounds and playing fields, at work, and very often, in motor vehicle accidents. The result is a large number of people who experience the broad range of difficulties which can occur following a closed head injury, one of which is fatigue. Clinical experience suggests that the fatigue which follows a head injury is a major source of difficulty for some individuals, and can be a significant hindrance in their attempt to return to an active life. Fatigue, however, is a complex problem which involves many potential causes or contributing factors, both physical (such as the quality or quantity of sleep an individual gets) and emotional (depression and stress, for example). All of these factors must be considered when attempting to evaluate the problem of fatigue in any given individual. Despite the frequency with which fatigue is encountered in the head injured population, very little is actually known about this issue. The following research was designed to provide some information regarding the extent, severity, and persistance of fatigue following a closed head injury.

A closed head injury does not necessarily involve an injury to the brain. It is quite possible to sustain facial injuries, for example, without any damage to the brain. It is equally possible to injure the brain without ever having sustained a hit to the head, as in the case of severe shaking of the brain within the skull. The term "closed head injury" is commonly used and implies a brain injury. For purposes of clarity, "closed head injury" is defined here as being synonomous with a traumatic brain injury.

## Review of the Literature

### Epidemiology

Various surveys conducted in the United States and England have resulted in widely varying incidence figures for closed head injuries, ranging from 170/100,000 people (Hospital Discharge Survey) to 3,900/100,000 people (National Center for Health Statistics) (Rimel & Jane, 1983). A major survey done in the United States estimated the number of new head injuries to be 422,000 in 1974, a rate of 200/100,000 people (Kalsbeek, McLaurin, Harris, & Miller, 1980). This survey included only those admitted to hospital, therefore excluding those who died before reaching hospital, those whose injury was of a mild nature which was either undiagnosed or did not require hospitalization, and those who did not seek treatment. The majority of these injuries were sustained by males (280,000), under the age of 25 years (262,000), in motor vehicle accidents (207,000). The total monetary cost of these injuries in the United

States (including hospital costs, loss of earnings, rehabilitation costs, etc.) was estimated to be $2.4 billion in 1974 alone (Kalsbeek, et al, 1980). The actual number of head injuries is very difficult to determine because minor head injuries frequently go unreported (Jennett & Teasdale, 1981). It has been estimated that 7 million head injuries in total occur in the United States each year (Jennett, 1983). By extrapolation, roughly 700,000 head injuries would occur in Canada each year, if the rate were to be comparable (the actual rate in Canada remains to be determined). Although the precise figures are unknown, it is believed that the majority of head injuries are in the mild range (Jennett, 1983).

Pathophysiology of Head Injury

The two major categories of head injuries are open (or penetrating) and closed head injuries. In open head injuries the skull and meninges are broken whereas in closed head injuries these structures remain intact (Jennett, 1983). Open head injuries typically occur in shooting or stabbing incidents or when an individual is struck by an object such as a baseball bat or a hammer. Although not always the case, the pathophysiology of these two types of head injuries can be quite different and can result in very different clinical pictures. Traumatic unconsciousness, for example, is a very common sign of closed head injury, occurring even in mild concussions (Grafman & Salazar, 1987). In cases of penetrating head injury, unconsciousness is the exception rather than the rule (Grafman & Salazar, 1987). In civilian populations most head injuries are closed, and most of our knowledge about head injuries is derived from studies of closed head injuries (Jennett, 1983). Therefore, the balance of this discussion will be limited to closed head injuries.

Following a closed head injury, damage to the brain can result from two separate processes: primary, that is immediate damage due to the impact of the head injury, and secondary, that is damage which results from various bodily mechanisms which are triggered by the injury (Miller, 1983). There are two sources of primary damage to the brain in a head injury. The first of these is the actual impact itself. When the head is in collision with another object (as in acceleration/deceleration injuries in motor vehicle accidents) or when the brain collides with the skull (as in severe shaking of the head), brain tissue is subjected to considerable physical forces. The impact of the soft tissue of the brain against the hard, irregular skull results in localized contusions - tearing and bruising of brain tissue (Katz, 1992; Miller, 1983). Such injuries may be superficial or may extend throughout the entire depth of the cortex (Teasdale & Mendelow, 1984). Contusions are most frequently located on the underside of the frontal lobes and at the temporal poles of the brain, regardless of the site of impact (Teasdale & Mendelow, 1984).

The second, and often more damaging, mechanism of traumatic brain injury is the rotational force which is applied. The brain is loosely anchored and surrounded by fluid. It is therefore capable of considerable rotation within the skull until its nerve fibers become severely stretched (Vogenthalen, 1987). This rotation leads to shearing injuries to the white matter (axons) throughout the brainstem and to the cerebral cortex (Teasdale & Mendelow, 1984). These injuries are often microscopic and may be difficult to detect using conventional medical imaging techniques (Miller, 1983). Nevertheless, it is these shearing, axonal injuries which are believed to be responsible for unconsciousness and for the diffuse areas of damage seen in most cases of closed head injury (Teasdale & Mendelow, 1984). Even in minor injuries, the basis for brief unconsciousness is believed to be diffuse axonal injury in which most of the axons recover (Teasdale & Mendelow, 1984). As with contusions, these microscopic lesions tend to be concentrated in the frontal and temporal areas of the brain (Grubb & Coxe, 1978; Katz, 1992).

Secondary damage to the brain can result from a number of different mechanisms which develop from the original injury. These include such problems as hypoxia, intracranial bleeding, swelling of the brain and elevated intracranial pressure, hydrocephalus, and post-traumatic epilepsy (Miller, 1983). Such secondary developments can cause damage to an already injured brain. Improvements in the medical management of these secondary sources of damage have contributed to a reduction in the mortality rate from severe head injury and thus to a large and growing population of survivors of serious head injuries (Levin, Grafman, & Eisenberg, 1987). Unconsciousness is an obvious sign of damage to the arousal systems of the brain. Once the individual has regained consciousness, however, problems with arousal and with sleep are less obvious and may be due to a number of factors.

Pathophysiology of Sleep and Arousal

There are several types of sleep disturbances discussed in the literature, ranging from insomnia to hypersomnia. The causes of the specific disturbances of sleep and arousal are not always clear, although the reticular activating system has long been assumed to be responsible for the maintenance of general cortical tone (Luria, 1973). Animal studies begun in 1949 by Moruzzi and Magoun have demonstrated that stimulation of this system leads to arousal while lesions in the same area lead to a decrease in cortical tone and sometimes to a coma state (Moruzzi &

Magoun, 1949; Lindsley, 1960; Pribram, 1971). This system has also been shown to have an important role in the orienting response necessary for selective attention (Gardner, 1975). The reticular formation is a network of cells located in the mid-brain with connections to and from the cortex (particularly to the frontal areas) and to other structures in the diencephalon such as the thalamus and hypothalamus (Hinebaugh, 1986; Luria, 1973). Theoretically, then, damage at any point in this extensive system could lead to problems in arousal and attention.

Sleep appears to be a very complex function. There are multiple structures and systems within the brain which play a role in the regulation of sleep. These include, but are not limited to, the locus ceruleus, the raphe, the hypothalamus, and cells in the midbrain and brain stem which produce norepinephrine, dopamine, and serotonin (Gardner, 1975; Carlson, 1981). Thus, damage to or disruption of a number of structures or chemical systems may lead to disturbance in the normal pattern of sleep.

Closed head injuries can result in diffuse damage to brain areas, shearing injuries to long fibers (such as those found in the reticular formation), and disruptions of the chemical balance of the brain (Kolb & Whishaw, 1980). The functions of arousal, attention, and sleep are all, therefore, vulnerable to disruption following a closed head injury.

Disabilities Resulting From Head Injuries

The pattern and level of cognitive, sensory, physical, and psychological strengths and weaknesses following a head injury will vary from individual to individual due to a number of factors: the pre-injury status of the individual in all of these areas plus the social and behavioral realms, the severity of the injury, the specific area(s) of the brain which has been injured, the quality of emergency and medical care which the person receives, the age of the person at the time of injury, the availability of rehabilitation services post-injury, the degree of social support available post-injury, etc.

The deficits which can occur following closed head injury span the entire range of functions which the brain normally controls. This includes the "physical, communicative, psychologic, social, educational, and vocational spheres of function" (Griffith, 1983, p. 23). A complete listing of the disabilities which have resulted from head injury would be extremely lengthy. There are, however, certain disabilities which occur more frequently than others. These include deficits in the acquisition and retention of information, decreased attention and concentration, slowed thinking, irritability, impaired judgement, changes in personality, difficulty with abstract thinking, impaired planning, and fatigue (Lezak, 1983; Griffith, 1983; Sbordone, 1984). While lists of symptoms vary from author to author, fatigue appears in most discussions of the after-effects of closed head injury.

When the injury is very minor, resulting in transient or no loss of consciousness, individuals may recover completely, although a significant minority will experience persistent difficulties (Vogenthaler, 1987). The resulting post-concussion syndrome consists of dizziness, headaches, irritability, impaired concentration and memory, easy fatigability, depression, alcohol intolerance, and oversensitivity to noise and light (Griffith, 1983; Rosenthal, 1983; Vogenthaler, 1987). In a three-center study of minor head injury, fatigability was the second most common complaint, with 55.5% of subjects reporting it (Levin, Gary, High, Mattis, Ruff, Eisenberg, Marshall, & Tabaddor, 1987). As early as 1934, an article written by Strauss and Savitsky listed "ready fatigability" as one of the three cardinal symptoms of minor head injury (along with emotional lability and difficulty in thinking).

Despite its prominent place in the symptom complex of closed head injury, a review of the psychological literature from 1970 to 1991 found no studies which specifically addressed the problem of fatigue after head injury. Clinical experience suggests that fatigue is a common complaint and that it can be a significantly disabling condition. It can compromise an individual's ability to return to work or to school, despite having recovered the necessary cognitive skills. It can limit the individual's activities to what he or she considers to be essential, with no energy available for the enjoyment of leisure activities. In short, fatigue can make a substantial impact on the quality of life for the person with a traumatic brain injury.

## Description of Current Research

Many questions regarding fatigue after closed head injury wait to be answered. Is fatigue a universal after-effect of head injury? If not, what percentage of head injured individuals experience fatigue as a problem in their lives? Is either the presence or the severity of fatigue related to the severity of the head injury, as defined by the length of post-traumatic amnesia? When present, does fatigue change over time, getting better or worse as the time since injury lengthens? These are some of the questions which will be addressed in the current research. When considering these questions several other factors, in addition to the head injury, must also be taken into account, due to their known relationship with fatigue and to the frequency with which they occur in individuals who have been injured. These factors are post-traumatic stress disorder and depression.

Post-Traumatic Stress Disorder and Closed Head Injury

Some articles discussing the symptoms frequently seen after closed head injury list "insomnia" rather than "fatigue" (Patten & Lauderdale, 1992). It is essential that fatigue due to insomnia be distinguished from fatigue without insomnia since both the cause and the treatment may depend upon which of these two problems an individual is experiencing. For instance, insomnia may be due to the development of Post-Traumatic Stress Disorder, in which both nightmares and a sleep disturbance are common symptoms (American Psychiatric Association [APA], 1980). Post-Traumatic Stress Disorder (PTSD) is commonly seen in populations of head injured individuals due to the preponderance of motor vehicle accidents in this group and the emotionally stressful nature of such accidents. This is especially true in the case of individuals with minor head injuries whose memories of the accident may be intact or very nearly so. If PTSD is the cause of an individual's insomnia and consequent fatigue, it should be identified and treated as soon as possible since this condition is relatively amenable to treatment. The current research is limited to a study of fatigue without insomnia.

Clinical Depression and Closed Head Injury

A possible confounding variable when studying fatigue after head injury is depression. Several weeks or months following closed head injury, many individuals experience depression (Lishman, 1978). This depression may be a reaction to the cognitive or emotional difficulties which resulted from the injury, may be a product of altered brain chemistry secondary to the injury, or may reflect a pre-existing personality component (Prigatano, 1987). Depression develops after head injuries of all severity and may be marked even after minor injuries (Lishman, 1978; Silver, Yudofsky, & Hales, 1991).

One of the most common symptoms of a depressive episode is a sleep disturbance (APA, 1980; Buchwald & Rudick-Davis, 1992). This sleep disturbance usually takes the form of insomnia but can also occur as hypersomnia in which case the individual sleeps much more than usual (APA, 1980). Even without an actual sleep disturbance, a decrease in energy is almost always present in depression and is experienced as chronic fatigue by the sufferer (APA, 1980; Buchwald and Rudick-Davis, 1992). Therefore, when studying fatigue in this population it is necessary to include a measure of depression to determine whether depression is a possible factor in the presence of fatigue after head injury.

Alertness and Vigilance Following Closed Head Injury

The ability to remain alert is necessary for normal daily functioning and is important for the safe execution of many activities (for example, driving or operating machinery). Lapses in alertness and decreases in vigilance over time in normal subjects have been the subjects of considerable research in the past several decades, as military and industrial developments have led to an increased number of jobs requiring sustained alertness (van Zomeren, Brouwer, & Deelman, 1984). Tonic alertness is "a continuing receptivity to stimulation, covering minutes or hours" (van Zomeren, et al., 1984, p. 91). Tonic alertness is usually studied using vigilance and continuous reaction time tasks (van Zomeren, et al., 1984). Vigilance tasks often consist of a low event rate presentation of signals which differ only in length or intensity (Posner, 1978). In normal subjects, a decrease in signal detection occurs within half an hour and this vigilance decrement is accompanied by EEG and behavioral signs of drowsiness (Brouwer & van Wolffelaar, 1985; Posner, 1978; van Zomeren, 1984). Many of the difficulties in activities of daily living encountered by individuals who have experienced a closed head injury have been theorized to be due to a generally low level of alertness (Gronwall & Sampson, 1974) or to an inability to sustain attention (Conkey, 1938; Ruesch, 1944). Neither of these theories have received support from recent studies using vigilance tasks (Brouwer & van Wolffelaar, 1985; van Zomeren, et al., 1984). Although the performances of the Closed Head Injury groups in these studies were worse than those of the normal controls from the outset, the size of the vigilance decrement across time was the same in both groups, and physiological measures (EEG and heart rate) indicated a possibly higher level of alertness in the Closed Head Injury group than in the controls (Brouwer & van Wolffelaar, 1985; van Zomeren, et al., 1984). It is possible that the Closed Head Injury groups were simply putting more effort into their performance than were the controls. In 1987, van Zomeren and Brouwer reported the results of a further study, also using an auditory vigilance task, in which the major finding was a relationship between drowsiness and performance on the task. In other words, those individuals who became drowsy showed a vigilance decrement while those who remained alert did not. Despite the overall lack of a vigilance decrement in this study, it did demonstrate a relationship between fatigue and attention. A more recent study, using subjects who had experienced mild head injuries, found similar results - that is, a lower overall target detection rate for the CHI group than for the Control group but no difference between the groups in the size of the vigilance decrement (Parasuraman, Mutter, & Molloy, 1991). Clinically, individuals who have sustained a head injury do complain of difficulty sustaining alertness throughout the course of a day. It seems premature to reject the hypothesis of a generally lower state of alertness or of difficulty sustaining alertness in these individuals on the basis of such a limited number of studies.

The differentiation between a lack of alertness and fatigue is subtle. While a decrease in alertness is a symptom of fatigue it may also be that the two problems are separate. It may be possible, for example, for an individual to remain alert despite feeling fatigued (although this may require greater effort than if one is not fatigued). Likewise, it may be possible to experience a lack of alertness due to problems other than fatigue (stress, or anxiety, or preoccupation, etc.) The relationship between a lack of alertness and fatigue may be complex and is not yet fully understood.

An Operationalized Definition of Fatigue

The definition of fatigue is problematic. To the layman, fatigue is a state which is difficult to describe precisely but which also is "so recognizable as to need no description" (Welford, 1953, p. 3). We all know what fatigue feels like from a subjective, personal perspective. The difficulty arises when trying to devise a definition of fatigue which allows objective measurements to be made, so that fatigue can be quantified and compared across individuals (Murray, 1992). For the purposes of this research, fatigue will be defined as : 1) sleeping for a greater amount of time, on average (as reported in a sleep log and as compared to non-injured controls); 2) difficulty sustaining alertness over time (as measured by a vigilance task, a sleep onset measure, and a subjective alertness measure); and 3) subjective complaints of feeling tired or lacking energy on a chronic basis (as measured by a vitality scale). These definitions yield several different measures which together can provide an indication of fatigue levels across individuals.

Hypotheses

The following hypotheses were generated from the above-mentioned considerations and from the definition of fatigue and were examined in this research:

1. The Control group and Closed Head Injury (CHI) group (in total) will be significantly different across all measures, as follows:
   - (a) Depression Scale - the CHI group will report more depressive feelings (higher scores) than will the Control group.
   - (b) Vitality Scale - The CHI group will report less vitality (higher scores) than will the Control group.
   - (c) Vigilance task - the CHI group will perform worse initially and will have

a larger vigilance decrement across time than the Control group.

(d) Sleep Onset task - the CHI group will have more incidences of key closure (touches) and the task will last for a shorter duration than will the Control group.

(e) Alertness Scale - the CHI group will report feeling less alert (lower scores) than will the Control group.

(f) Sleep Log - the CHI group will report more hours spent sleeping than will the Control group.

2. There will be differences between the CHI subgroups (Minor and Severe) in the form of a linear relationship between severity of closed head injury and results on the Vitality scale, the Vigilance task, the Sleep Onset task, the Alertness scale, and the Sleep Log. In all cases, the Minor CHI group will have less evidence of fatigue than will the Severe CHI group.

3. There will be no significant difference between the CHI subgroups on the results from the Depression scale.

4. When the results are analyzed according to time-since-injury rather than severity, there will be a lessening of fatigue indices across time for both CHI subgroups.

# CHAPTER TWO

## Methodology

### Subjects

The subjects used were all either past or present patients in the Head Injury Rehabilitation program of a local hospital (Gorge Road Hospital, Greater Victoria Hospital Society, Victoria, B.C.). Individuals enter this program through one of two routes: a) transferred from an acute care hospital for the rehabilitative phase of their treatment (typically following moderate or severe head injuries) or b) referred by physicians from the community (often following minor head injuries which did not lead to hospitalization). For entry into the rehabilitation program, individuals must first be screened by an admitting panel (a physiatrist, a neuropsychologist, and a social worker) and must fulfill the following requirements:

1) they must have sustained a head injury and this injury must have had an impact on their ability to function in their daily lives;
2) they must have the potential to improve (in the judgement of the admitting panel) in at least one of a variety of cognitive, behavioral, physical, or emotional areas;
3) they must agree to abstain from the use of alcohol or other intoxicants for the duration of their

treatment;

4) they must demonstrate sufficient motivation and committment to the rehabilitation process (again, in the judgement of the admitting panel).

Individuals are not excluded by monetary considerations (providing that they have provincial medical coverage) nor by pre-set cognitive standards (e.g., IQ level). The admitting panel also screens potential patients for signs of PTSD and/or significant depression by asking certain key questions in the interview process (about the individual's mood, for example, or the presence of nightmares or changes to significant relationships). Because both of these conditions can lead to complaints which are similar to those which may follow a minor head injury (for example, fatigue, difficulty with concentration or attention, slowed thinking, difficulty with memory), because their presence can impair recovery from a coincident head injury, and because their treatment is essentially different from that for a closed head injury, individuals with either of these conditions are referred elsewhere in the community for the appropriate treatment before they can be considered eligible for the rehabilitation program. Thus, the subjects used in this study were drawn from a pool of individuals who had already been screened and/or treated for both PTSD and depression.

The subjects had experienced a range of severity of head injury, from minor to severe (post-traumatic amnesia ranging from less than one hour to greater than 24 hours, according to Russell's (1971) classification). All of the subjects were either out-patients (i.e., not resident in the hospital) currently in the rehabilitation program or had been discharged from the program at the time of their participation in the study. They were a minimum of three months post-injury. Subjects were between the ages of 16 and 40 at the time of injury. This latter criterion was to avoid the introduction of variability due to the special effects of head injury in the very young (when the brain is still developing) or in the later years (when the aging process has begun).

Subjects were excluded if they had a history of psychiatric illness or if they were not able to reach an acceptable level of proficiency on one of the tasks used (the Vigilance task). They were not excluded on the basis of a history of drug or alcohol abuse. Alcohol abuse in particular is common in individuals who experience head injuries (Bond, 1984; Grafman & Salazar, 1987). One study found that 25% of their head injured group had received professional treatment for alcohol abuse (Rimel & Jane, 1983). To exclude subjects on the basis of their previous pattern of alcohol use could, therefore, result in a sample which would not be representative of the general population of head injured individuals. None of the subjects used in this study had experienced a previous head injury which had required treatment of any kind. The subjects used were not selected for the presence or absence of fatigue. Files on participants in the Head Injury Rehabilitation program were simply examined alphabetically. Individuals were selected who met the previously listed criteria, who were available and willing, and who could provide the researcher with the name of an appropriate person to act as a control.

The Control group was composed of friends or relatives of the CHI group. These individuals can be expected to be more similar to the subjects in terms of demographic variables, such as education and socio-economic status, than would a group drawn from the general population or from such convenient groups as hospital employees or university students (Dikmen & Temkin, 1987). Friends and relatives are also likely to be comparable to the CHI group in such hard-to-measure aspects as risk-taking or psychosocial adjustment (including pattern of alcohol use) (Dikmen & Temkin, 1987). The same exclusion criteria were applied to the Control subjects as to the subjects in the CHI group.

The Control subjects were matched to the CHI subjects through a two-step interview procedure. The first step was to ask each CHI subject for the name of a friend or relative who, prior to the head injury, was similar to him or herself on the following psychosocial variables:

A) lifestyle - for example, hobbies, activities, living situation, etc.;

B) personality - likes/dislikes, sense of humour, willingness to take risks, etc.;

C) background - educational or employment history, characteristics of the family of origin, etc.;

D) demographics - same sex, same age (± 5 years).

The second step involved contacting the potential Control person to confirm this similarity from the Control's perspective and then to determine the Control's willingness to participate in the research.

All of the subjects were given an intentionally vague explanation of the purpose of the study (i.e., the word "fatigue" was mentioned but as just one of several potential after-effects of closed head injury, such as depression and attentional difficulties). This was done to minimize the risk of subjects deliberately over-reporting symptoms of fatigue, perhaps in an attempt to "help" the researcher. This was a concern since the researcher knew most of the CHI subjects and had been involved in their rehabilitation programs. In addition to the above, all subjects were given a detailed description of the measures used and the requirements of participants in the study. After receiving the explanation and prior to data collection, each subject was given an opportunity to ask questions and was asked to sign a consent form (the under-age subjects were given a parent/guardian consent form - see Appendix A for copies of both these consent forms).

The subject pool consisted of more than 150 CHI individuals who were past or current participants in the rehabilitation program. Of these, 75 met the requirements of this study and either lived within the Greater Victoria area or frequently visited the area and so could come to the hospital where the data was gathered. Many of these people, however, were unable to provide the name of even one same-sex friend or family member to act as their control. This was the case even for some individuals who had lived in the same area for a number of years. While not part of this study, this was an interesting observation and perhaps is indicative of the social isolation which is reportedly very common after a head injury.

It had originally been planned to include a moderate CHI group (post-traumatic amnesia of from one to twelve hours in duration [Russell, 1971]), however, inspection of the subject pool revealed a decided paucity of individuals who would fit in such a group. It is not known whether this reflects a generally found trend among CHI patients or whether this is due to the referral patterns in this particular community. At any rate, it quickly became evident that there were not enough individuals who had experienced a CHI of moderate severity to enable such a group to be included in the study.

The target sample size was originally 30 CHI subjects and 30 matched Control subjects but this figure had to be revised downwards slightly due to the problems encountered in obtaining appropriate individuals. This very slight down-sizing was not considered to be significant in terms of the interpretation of the results.

The final CHI subject group consisted of 28 individuals (14 Minor and 14 Severe), each one matched with a friend or family member of the same sex. Of these, six individuals (all Control subjects) did not complete or return the Sleep Log and Alertness Scale. The final analyses, therefore, were based on 28 pairs of subjects for the first four measures and 22 pairs for the last two. All of the subjects, both Controls and CHI, were unpaid volunteers.

Measures

The following measures were used in this study: Depression Scale - developed by the Rand Corporation, this very short (3 - item) questionnaire correlates reasonably well with other, more commonly used depression scales (Self-Rating Depression Scale, $r = .70$, $p < .05$; Beck Depression Scale, $r = .61$, $p < .05$) (Ware, Johnston, Davies-Avery, & Brook, 1979). The commonly used depression scales all contain items which relate to vegetative signs (e.g., changes to sleep pattern, changes in eating habits) or cognitive difficulties (e.g., difficulty making decisions, difficulty initiating behavior) all of which can be symptoms of closed head injury. In contrast, this questionnaire contains only items of an emotional nature and so its use in this population hopefully eliminates one source of potentially confounding information. The scale measures an individual's subjective experience of his or her emotional state over the previous month (see sample in Appendix A).
Vitality Scale - also developed by the Rand Corporation, this 4 - item questionnaire is an attempt to measure the individual's subjective energy level over the previous month (see sample in Appendix A).

Both of these Scales have been investigated and found to be reliable measures with good construct and content validity (Nelson, Kirk, McHugo, Douglass, Ohler, Wasson, & Zubkoff, 1987). The two Scales were administered in a balanced fashion, with every other CHI subject and every other Control subject completing them in the above order and the intervening subjects completing them in the reverse order.

The following two measures were both administered via a computer. This was a standard personal computer to which a telegraph key assembly had been added. As with the Scales, these measures were also administered in a counter-balanced order.

Vigilance Task - The subjects were seated in a chair, facing away from the computer screen, with the telegraph key assembly placed on a table in front of them.
The subjects were asked to rest the index finger of their dominant hand beside the telegraph key. A series of tones was delivered by the personal computer at the rate of one tone every 2 seconds. The target tones were 20 pseudorandomly dispersed tones which were of shorter duration than the standard tones (375 msec. versus 500 msec.). The subjects were instructed to depress the telegraph key each time a shorter tone was detected. The frequency of the tones was a function of the computer itself

and could not be changed but the intensity could be raised or lowered to make it more comfortable for the subjects. Subjects were given a short (5-minute) practice session which could be repeated once, if necessary. In order to be included in the study, each subject was required to reach an accuracy level of 70% on the practice task (i.e., no more than 30% of responses being false positives or missed targets). All subjects were able to meet this criterion. This criterion effectively excludes those individuals with very severe deficits in attention. The task itself was 30 minutes in length. The computer recorded the number of false positives and missed targets per ten-minute segment of each session. This is a similar vigilance task to that employed by Broughton, Low, Valley, Da Costa, and Liddiard in their 1982 study of excessive daytime sleepiness in narcolepsy - cataplexy, although the task in the 1982 study was 60 minutes in length and contained 40 target tones.

<u>Sleep Onset Task</u> - This was designed to be a behavioral measure of drowsiness. The subjects were in the same room and the same chair as in the above measure. There was no one else in the room nor was there any reading material or music provided. The subjects were asked to poise the middle finger of their dominant hand over the telegraph key. The telegraph key was on a moveable board and subjects were encouraged to move it to where ever they felt the most

comfortable. The telegraph key was adjusted to a very sensitive level so that any jostling or moving about by the subjects could result in a key closure. The subjects were instructed to try to keep their finger lightly resting on the telegraph key so that the key was not depressed. A slight upward tension of the finger was needed to avoid key closure. The subjects were told that if the key was depressed they should simply raise their finger to its former position. The computer recorded the number of key closures (touches) and the duration of the task (up to a maximum of 30 minutes or 15 touches). This measure has been found to be closely associated with EEG indices of drowsiness and sleep onset (Perry & Goldwater, 1987).

The following two measures were to be completed by the subjects at home, over the course of the next week. Subjects were given detailed instructions as to how to complete each of these measures.

Alertness Scale - Subjects were given a booklet in which to record their subjective level of alertness on a twice-daily basis for one week. On a line ranging from 1 (almost asleep) to 5 (exhilarated, excited), the subjects were instructed to indicate their subjective level of alertness by drawing a slash (/) through the spot on the line which best described their current state of alertness. This was to be done once approximately mid-morning and once approximately mid-afternoon, every day, for one week. If the subjects forgot to complete this scale at any time, they were instructed <u>not</u> to try to complete it according to their memory of how they had felt at that time but, rather, to begin anew on the next morning. This could extend the process of completing this scale by several days. These subjective rating scales have been shown to correlate well with physiological measures which are believed to be reliable indicators of fatigue (Zinchenko, Leonova, & Strelkov, 1985). Calculations were performed on the completed booklets to compute the average level of alertness in the morning, in the afternoon, and overall (see sample booklet in Appendix A).

<u>Sleep Log</u> - Subjects were given a booklet in which to record the hours they slept each day for one week. This was to include naps during the day as well as the hours slept at night. If sleep was interrupted for longer than 15 minutes (due to a nightmare, for example) this was to be noted in the log as well. The completed logs yielded the total number of hours slept each week from which an average amount per day was calculated (see Appendix A for sample booklet).

<u>Pilot Study</u>

A pilot study consisted of seven pairs of subjects, three of which were in the Severe CHI group and four in the Minor CHI group. No difficulties were encountered with any of the procedures or with the subjects' ability to comply with the requirements, and there was a clear difference between the CHI and Control subjects on all the measures. For visual inspection of the results of the pilot study, see the graphs in the Results section, pair numbers 1, 2, 3, 4, 12, 13, and 14. Since no procedural changes were required, these seven pairs of subjects were included in the larger study.

Design and Statistical Analysis

This is a comparative study, designed to explore the potential differences between groups on a variety of measures. There was no manipulation of variables.

The first step in the analysis was to graph the results. Graphs were generated to compare all of the subject pairs (Control and CHI), to compare the Minor CHI and Control pairs, to compare the Severe CHI and Control pairs, and to compare the Minor and Severe CHI groups on the following measures: the Vitality Scale score, the Depression Scale score, the total number of errors on the Vigilance test, the number of touches (key depressions) on the Sleep Onset task, the duration of the Sleep Onset task, the average AM Alertness Scale score, the average PM Alertness Scale score, the total average on the Alertness

Scale, and the average number of hours slept per day according to the Sleep Logs.

The demographic characteristics of the groups were compared using t-tests (two-tailed) to test the similarity between the CHI group and the Control group. A nonparametric statistic, the Randomization Test for Scores (May, Hunter, & Masson, 1992), was used to examine the differences between the groups on all of the various measures (2000 permutations considered, two-tailed). The relationship between the length of time post-injury and the scores on the Depression Scale, the Vitality Scale, the total errors on the Vigilance task, the number of touches and duration of the Sleep Onset task, the total average on the Alertness Scale, and the average hours slept per day on the Sleep Log was examined with a Pearson r correlation analysis. A correlation was also performed to examine the relationship between the length of post-traumatic amnesia and the same measures.

Subsequent to these analyses, a further question arose. That was, what was the relationship between the scores on the measure of depression and each of the other measures? For exploratory purposes, it was decided to use a standard analysis of variance (2 X 2 ANOVA) and an analyis of covariance (with depression as the covariate) to look at this relationship.

Statistics were calculated through the use of the SPSS statistical analysis system (SPSS-Inc, 1988) (t-tests of demographic information, correlations, ANOVA and ANCOVA) and through the use of NPStat 3.7 (May, Hunter and Masson, 1992) (randomization test).

# CHAPTER THREE

## Results

### Demographics Information

Tables 1 and 2 contain the demographic information for all subjects as well as comparisons between the groups on the variables of age, years of education, length of post-traumatic amnesia (in hours), and length of time post-injury (in months). At least in terms of these demographics, the matching process between CHI subjects and Control subjects was successful, as there was no significant difference between the groups on the variables of sex, age, and education.

The CHI groups, however, did differ on all demographic variables, as summarized in Table 2. The Minor CHI group was older than the Severe CHI group, had more years of education than the Severe CHI group, and more time had passed since their injury than for the Severe CHI group. By definition, the length of post-traumatic amnesia differed significantly between the two levels of severity. In addition, the gender composition of the two groups differed, although not significantly, with the Minor CHI group being predominantly female (5 males/9 females) and the Severe CHI group being predominantly male (8 males/ 6 females). With the exception of the difference on the post-traumatic amnesia variable, none of these differences was predicted and no attempt was made to match the two CHI subgroups on these variables.

CHI and Control Group Comparisons

Table 3 contains the comparisons between the total CHI group and the Control group on all measures. The results for the Depression Scale, the Vitality Scale, the Vigilance task, and the Sleep Onset task are based on scores from 28 subjects per group. The Alertness Scale and Sleep Log results are based on information from 22 subjects per group. The difference between the groups on the False Positives score of the Vigilance task is significant at the .05 level. The differences between the groups on all other measures are significant at the .005 level. These results can be examined visually in the graphs contained in Figures 1 - 9.

Table 1

Demographic Information for CHI and Control Groups

[Means (M), Standard Deviations (SD), and *t* values]

| Variable | | Group CHI | Control | t |
|---|---|---|---|---|
| Gender/N | | 13 M/15 F | 13 M/15 F | ns |
| Age (years) | M | 29.61 | 29.18 | 0.22 ns |
| | SD | 7.25 | 7.18 | |
| | Range | 16 - 41 | 17 - 43 | |
| Education (years) | M | 12.96 | 14.00 | -1.52 ns |
| | SD | 2.67 | 2.42 | |
| | Range | 10 - 20 | 10 - 20 | |
| Length of PTA (hours) | M | 293.31 | NA | NA |
| | SD | 702.09 | | |
| | Range | .08 - 3360 | | |
| Time Post-Injury (Months) | M | 21.89 | NA | NA |
| | SD | 15.28 | | |
| | Range | 4 - 61 | | |

ns - non-significant
NA - not applicable

Table 2

Demographic Information for Minor & Severe CHI Groups

[Means (M), Standard Deviations (SD), and *t* values]

| Variable | | Group Minor CHI | Severe CHI | t |
|---|---|---|---|---|
| Gender/N | | 5 M/9 F | 8 M/6 F | ns |
| Age (years) | M | 34.50 | 24.71 | 4.83*** |
| | SD | 3.67 | 6.64 | |
| | Range | 29 - 41 | 16 - 37 | |
| Education (years) | M | 14.29 | 11.64 | 2.97** |
| | SD | 2.58 | 2.10 | |
| | Range | 12 - 20 | 10 - 18 | |
| Length of PTA (hours) | M | 0.33 | 586.29 | -2.39* |
| | SD | 0.29 | 915.91 | |
| | Range | .08 - 1 | 48 - 3360 | |
| Time post-injury (months) | M | 27.93 | 15.86 | 2.24* |
| | SD | 16.54 | 11.53 | |
| | Range | 8 - 61 | 4 - 46 | |

ns - non-significant
* p <.05; ** p <.01; *** p <.005

Table 3

Comparisons Between CHI and Control Groups

On All Measures

[Means (M), Standard Deviations (SD) and *t* values]

| Variable | | Group CHI | Control | t |
|---|---|---|---|---|
| Depression | M | 8.86 | 5.29 | 5.04*** |
| Scale | SD | 2.98 | 2.28 | |
| Vitality | M | 16.07 | 10.29 | 8.56*** |
| Scale | SD | 2.81 | 2.21 | |
| Vigilance Task | | | | |
| False Pos. | M | 3.64 | 1.21 | 2.54* |
| | SD | 4.60 | 2.10 | |
| Missed Tar. | M | 1.86 | 0.36 | 3.49*** |
| | SD | 2.14 | 0.78 | |
| Total Errors | M | 5.50 | 1.57 | 3.56*** |
| | SD | 5.32 | 2.40 | |
| Sleep Onset Task | | | | |
| Touches | M | 8.86 | 2.32 | 4.73*** |
| | SD | 6.37 | 3.58 | |
| Duration | M | 24.14 | 29.59 | -3.35*** |
| | SD | 8.34 | 2.15 | |
| Alertness Scale (1) | | | | |
| Average AM | M | 2.65 | 3.14 | -3.36*** |
| | SD | 0.47 | 0.51 | |
| Average PM | M | 2.27 | 3.49 | -7.44*** |
| | SD | 0.54 | 0.47 | |

Table 3 (Cont)

| Variable | | Group CHI | Control | t |
|---|---|---|---|---|
| Alertness Scale (1) | | | | |
| Total Average | M | 2.46 | 3.28 | -7.60*** |
| | SD | 0.41 | 0.30 | |
| Sleep Log (1) | | | | |
| Average/Day | M | 9.15 | 7.87 | 3.71*** |
| (Hours) | SD | 1.36 | 0.88 | |

*p <.05; **p <.01; ***p <.005

NOTE: Estimated probabilities computed using the Randomization Test for Scores, 2000 permutations considered, 2 - tailed.

(1) Alertness Scale and Sleep Log comparisons are based on 22 subjects per group; all other measures have 28 subjects per group.

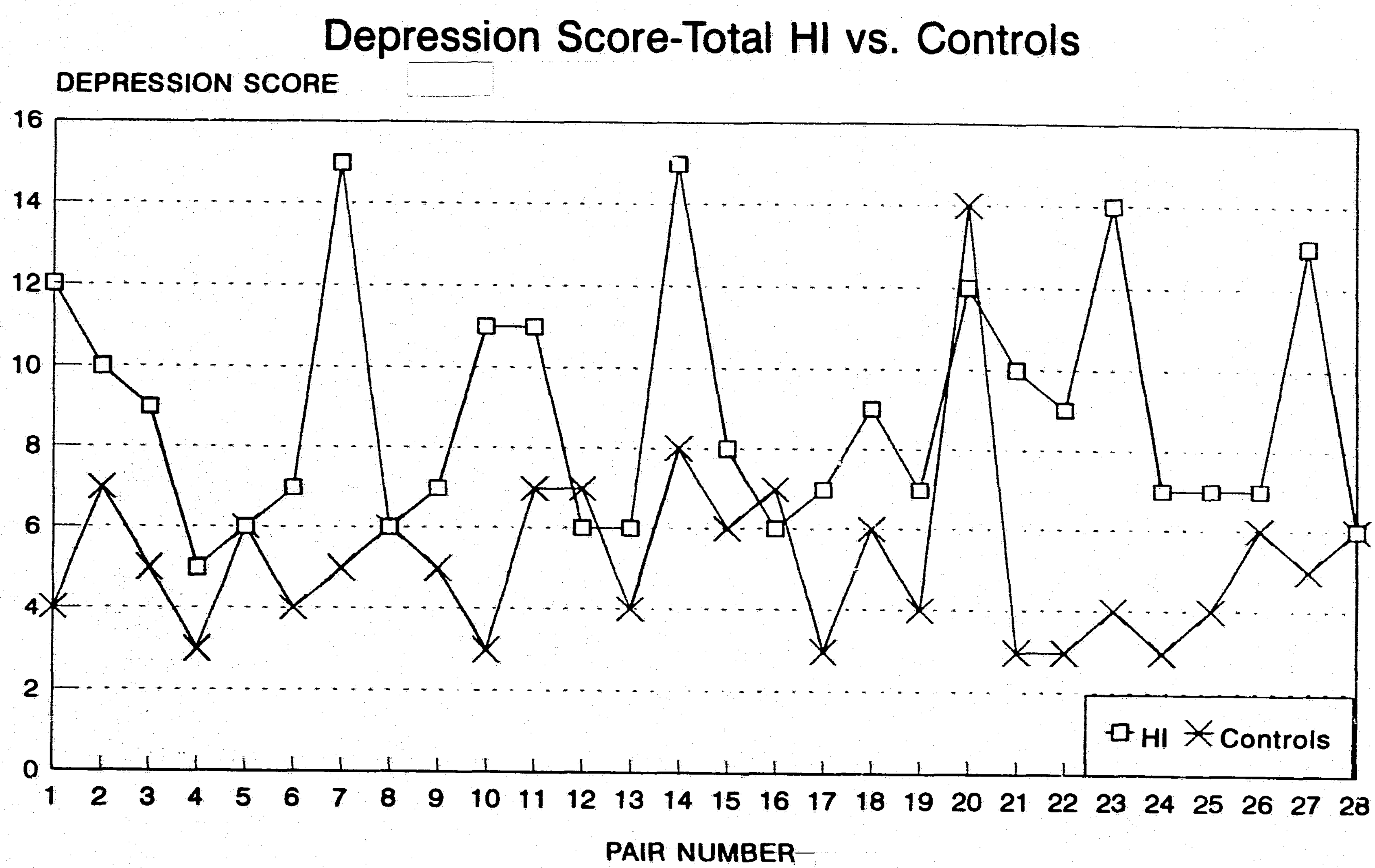


Figure 1. Depression Score for CHI Group vs. Control Group.

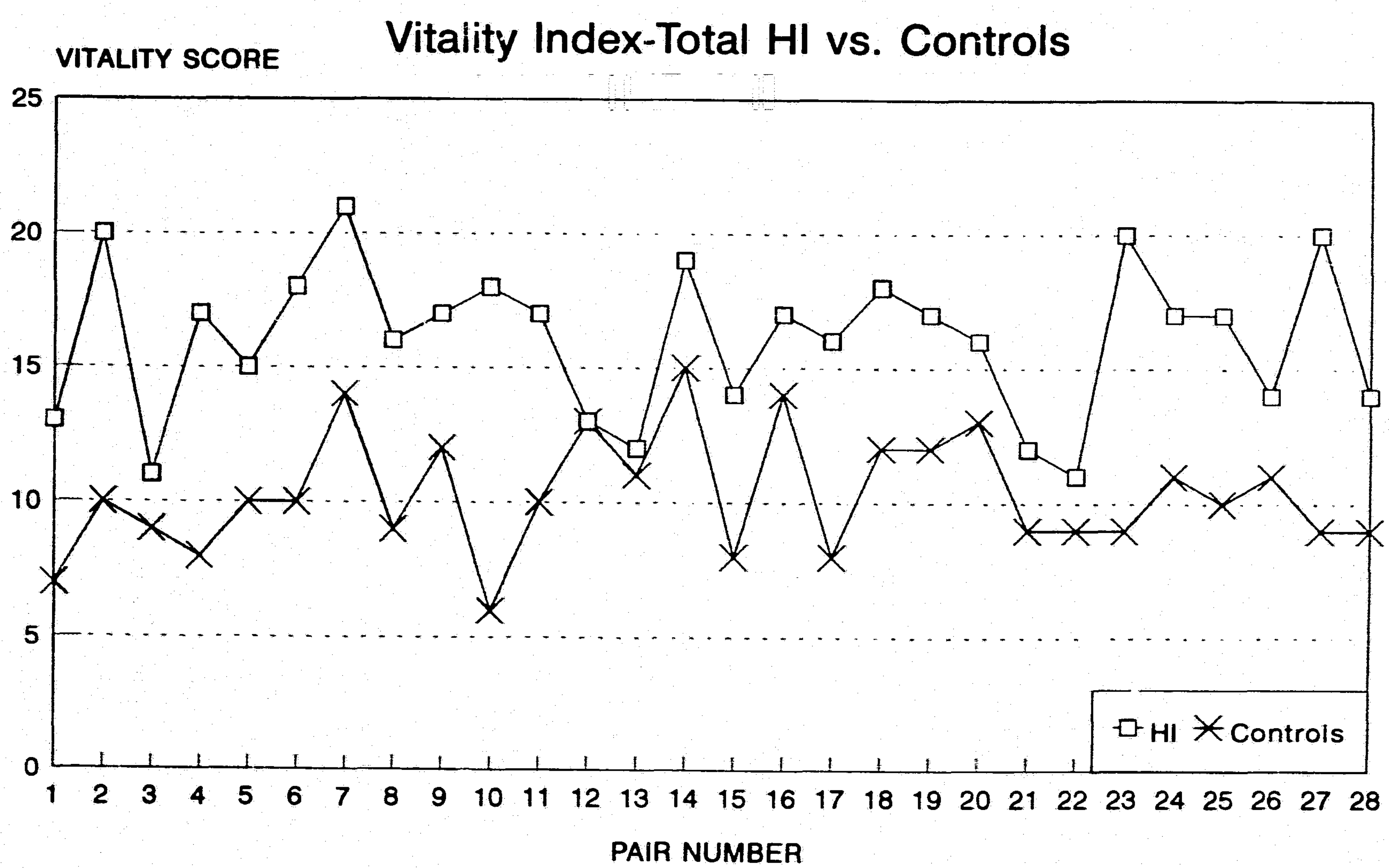


Figure 2. Vitality Index Scores for CHI Group vs. Control Group.

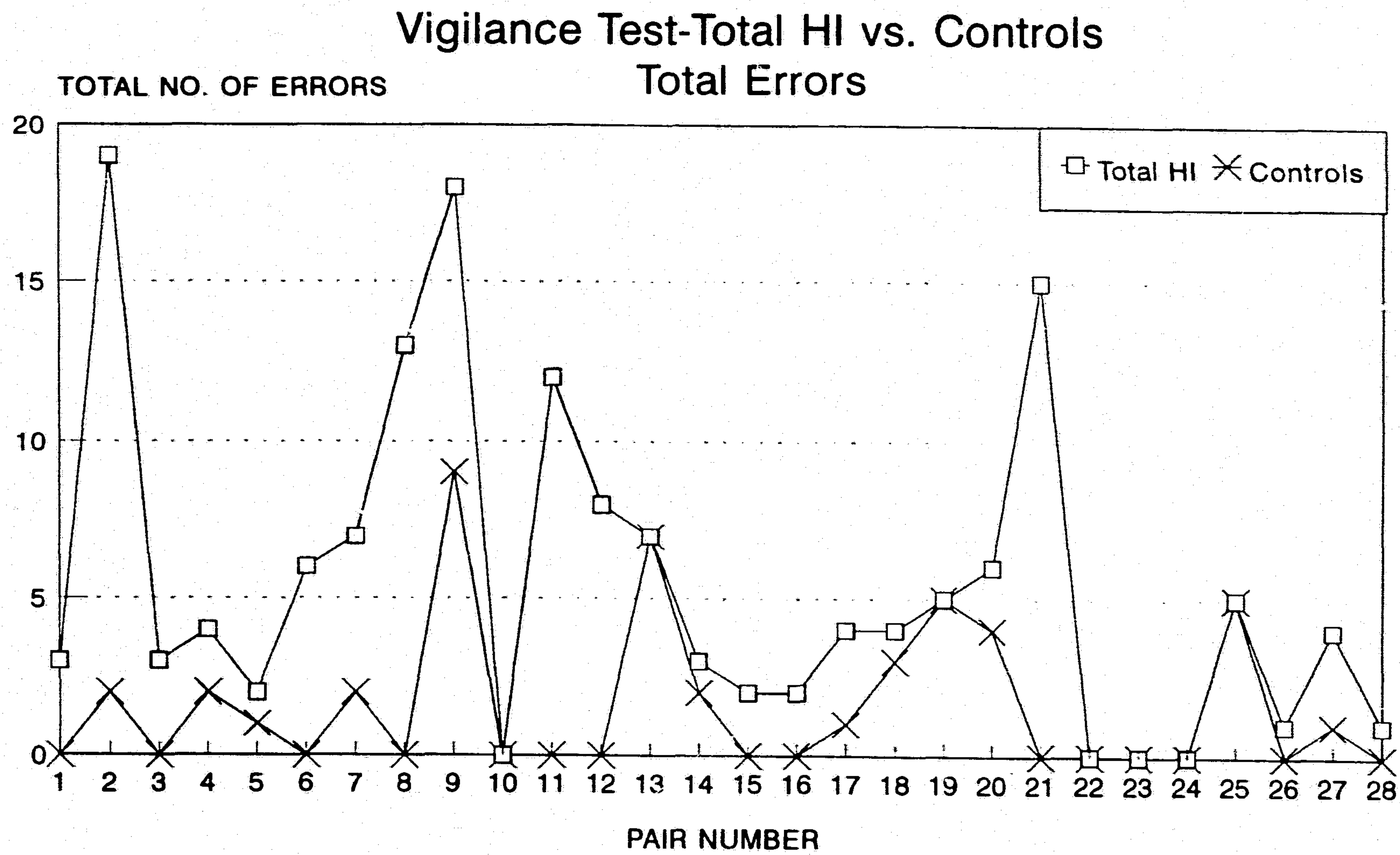


Figure 3. Vigilance Test-Total Number of Errors for CHI Group vs. Control Group.

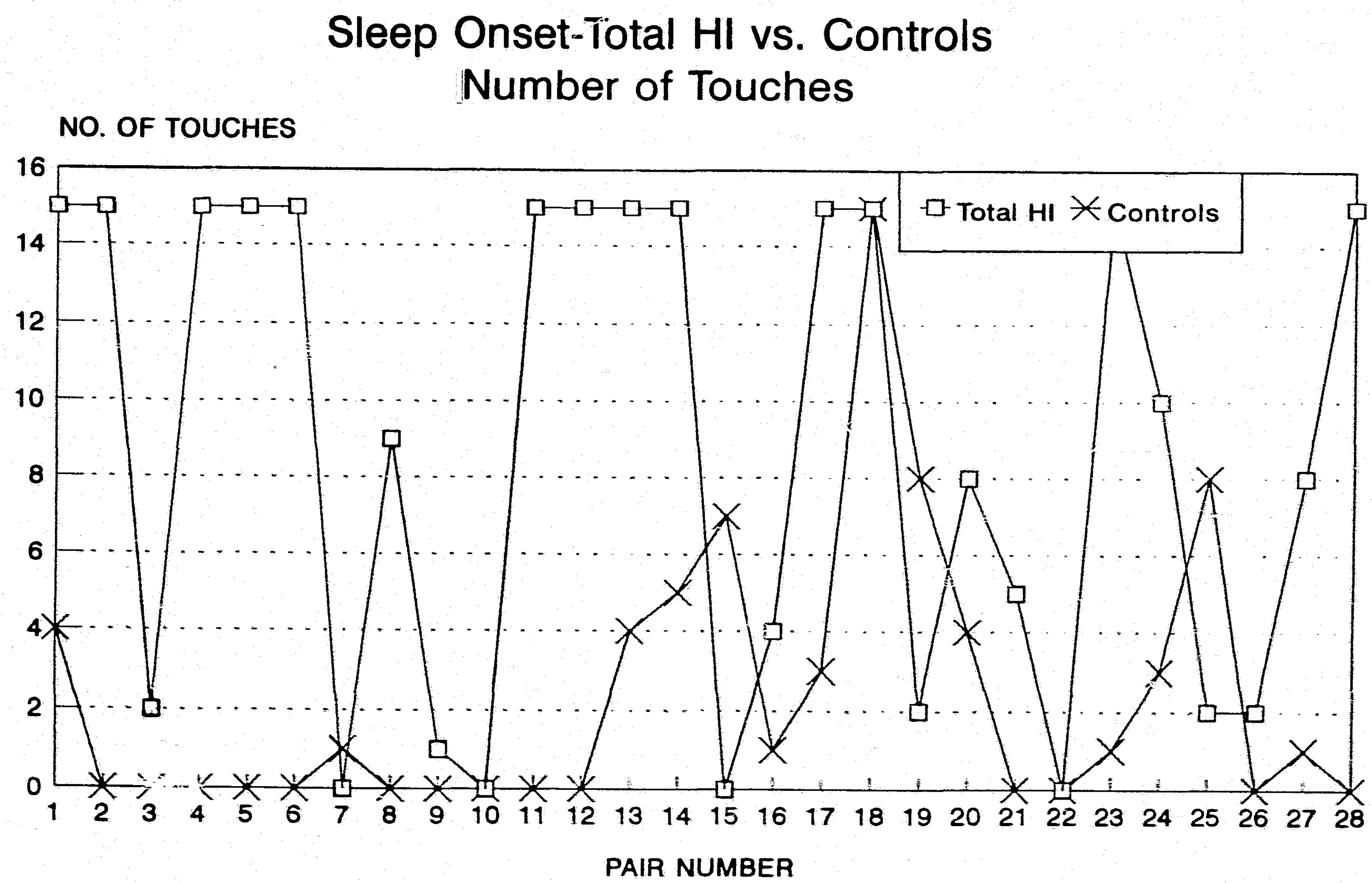


Figure 4. Sleep Onset Task-Number of Touches for CHI Group vs. Control Group.

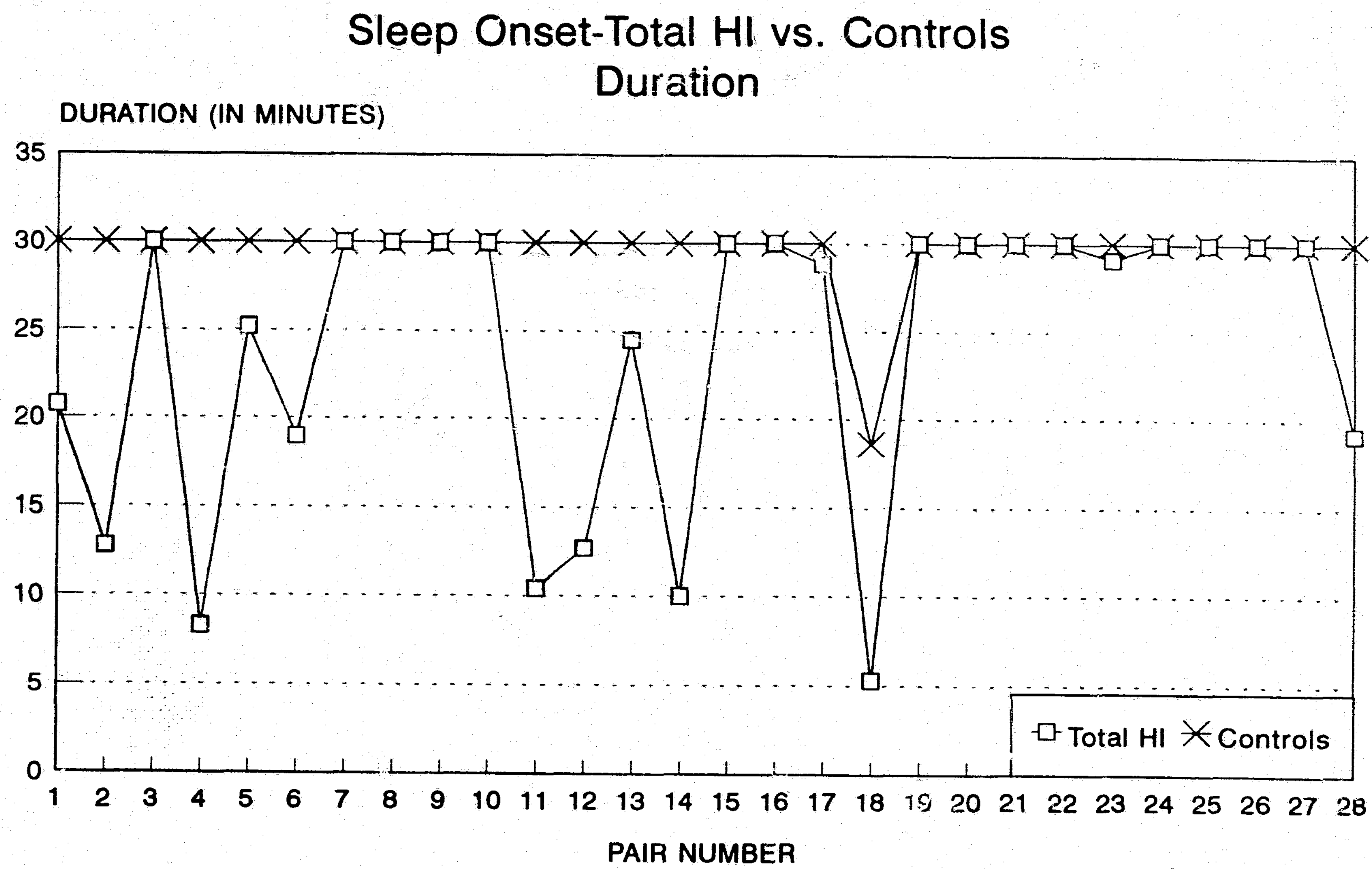


Figure 5. Sleep Onset Task-Duration for CHI Group vs. Control Group.

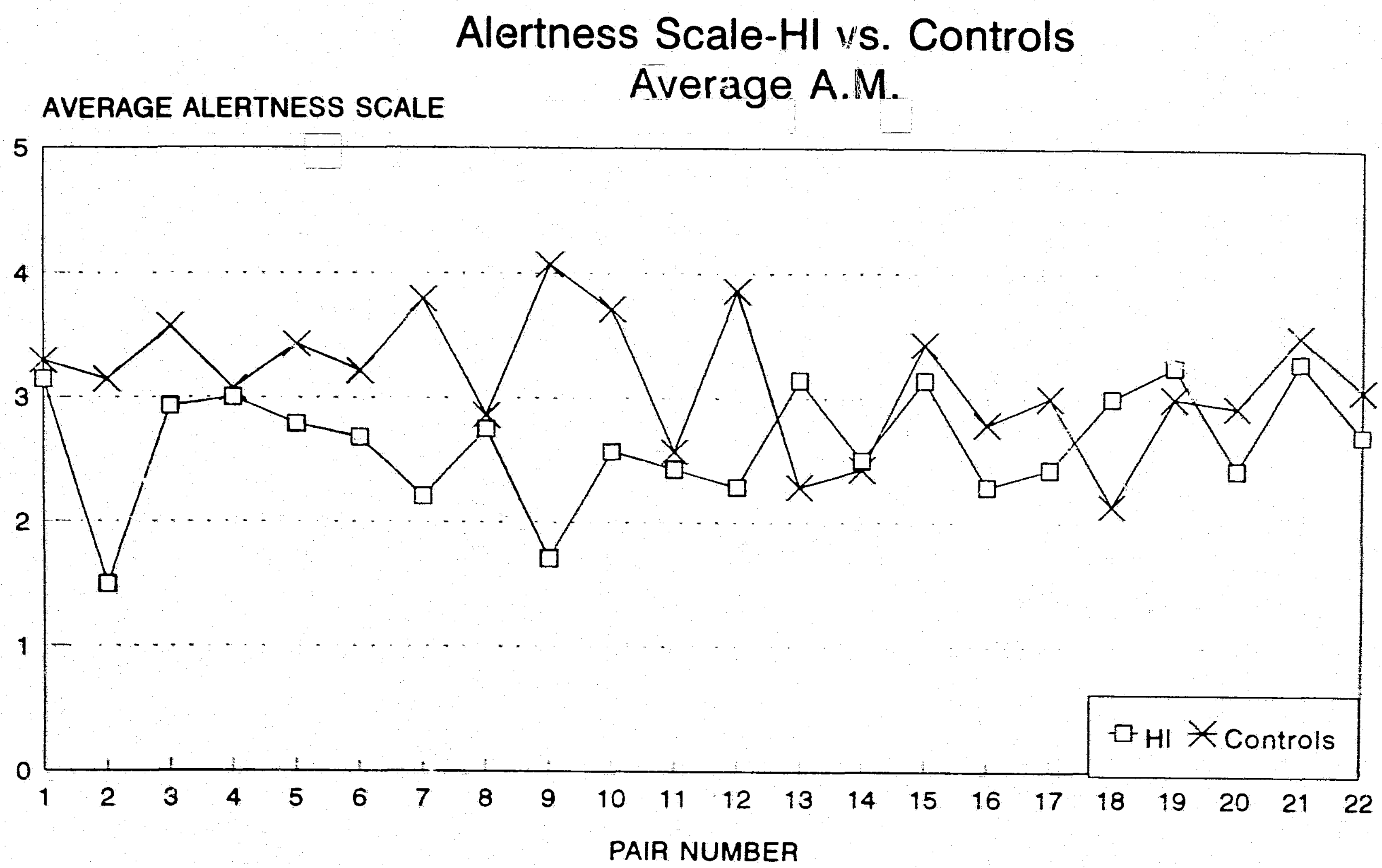


Figure 6. Alertness Scale-Average A.M. for CHI Group vs. Control Group.

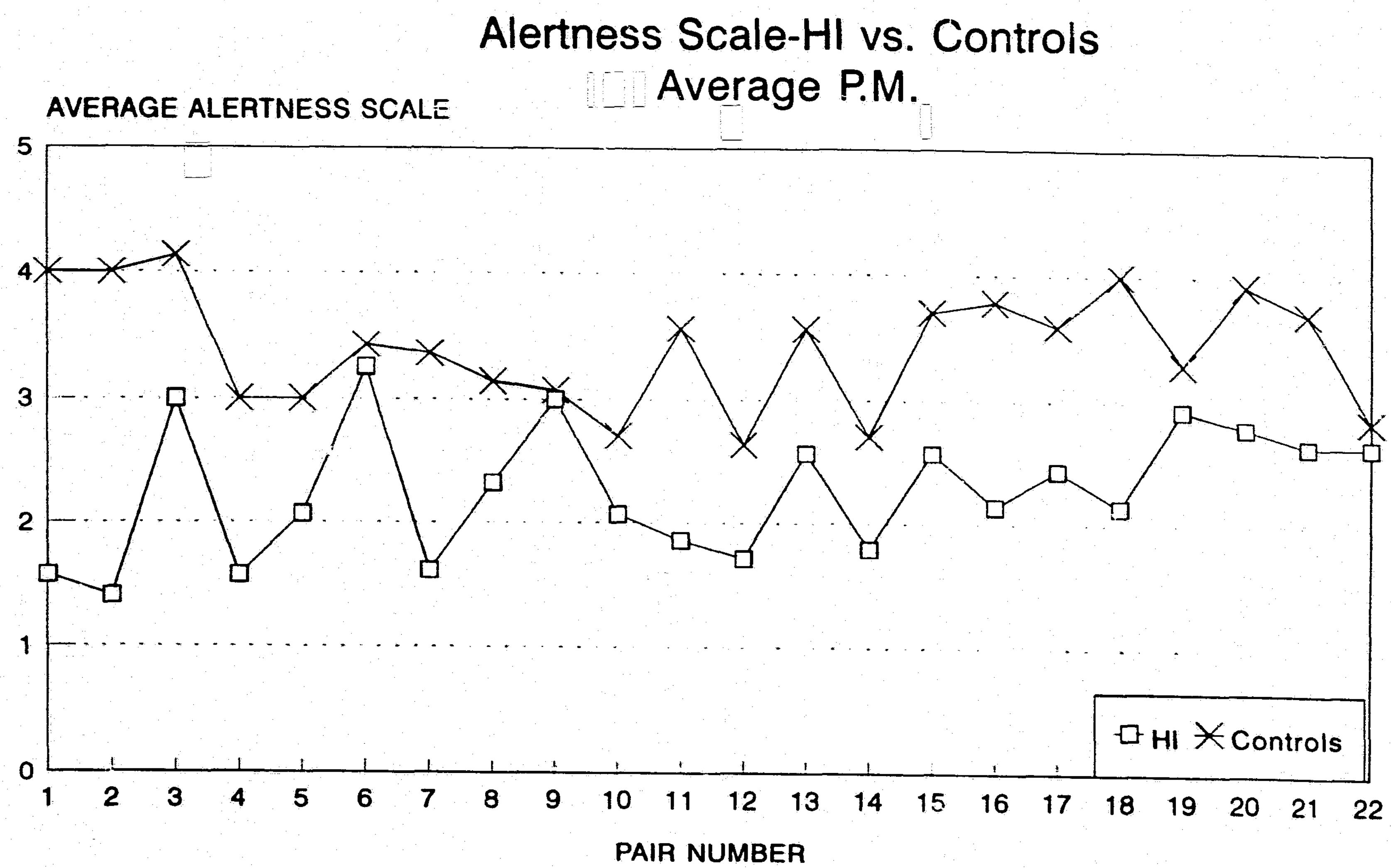


Figure 7. Alertness Scale-Average P.M. for CHI Group vs. Control Group.

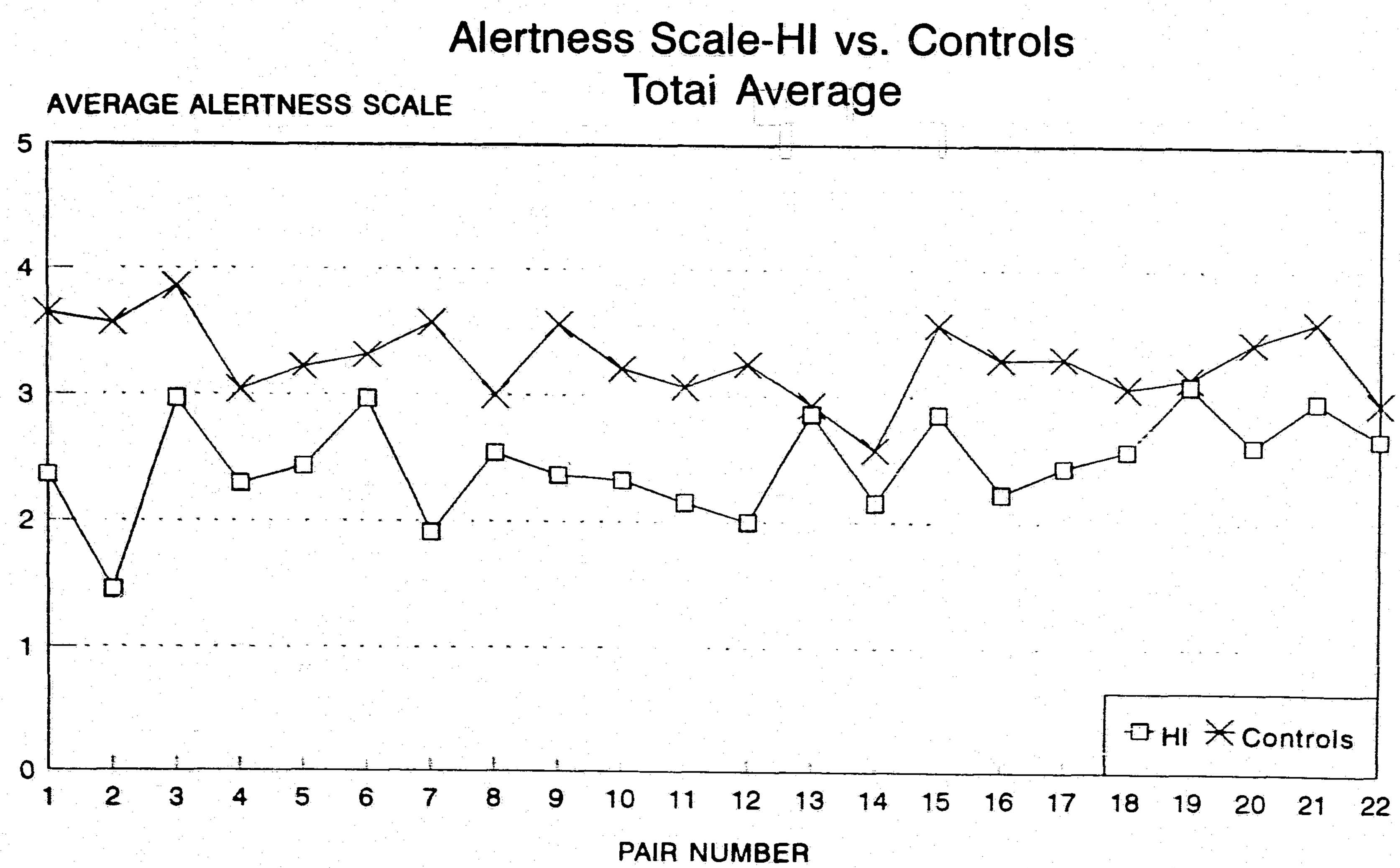


Figure 8. Alertness Scale-Total Average for CHI Group vs. Control Group.

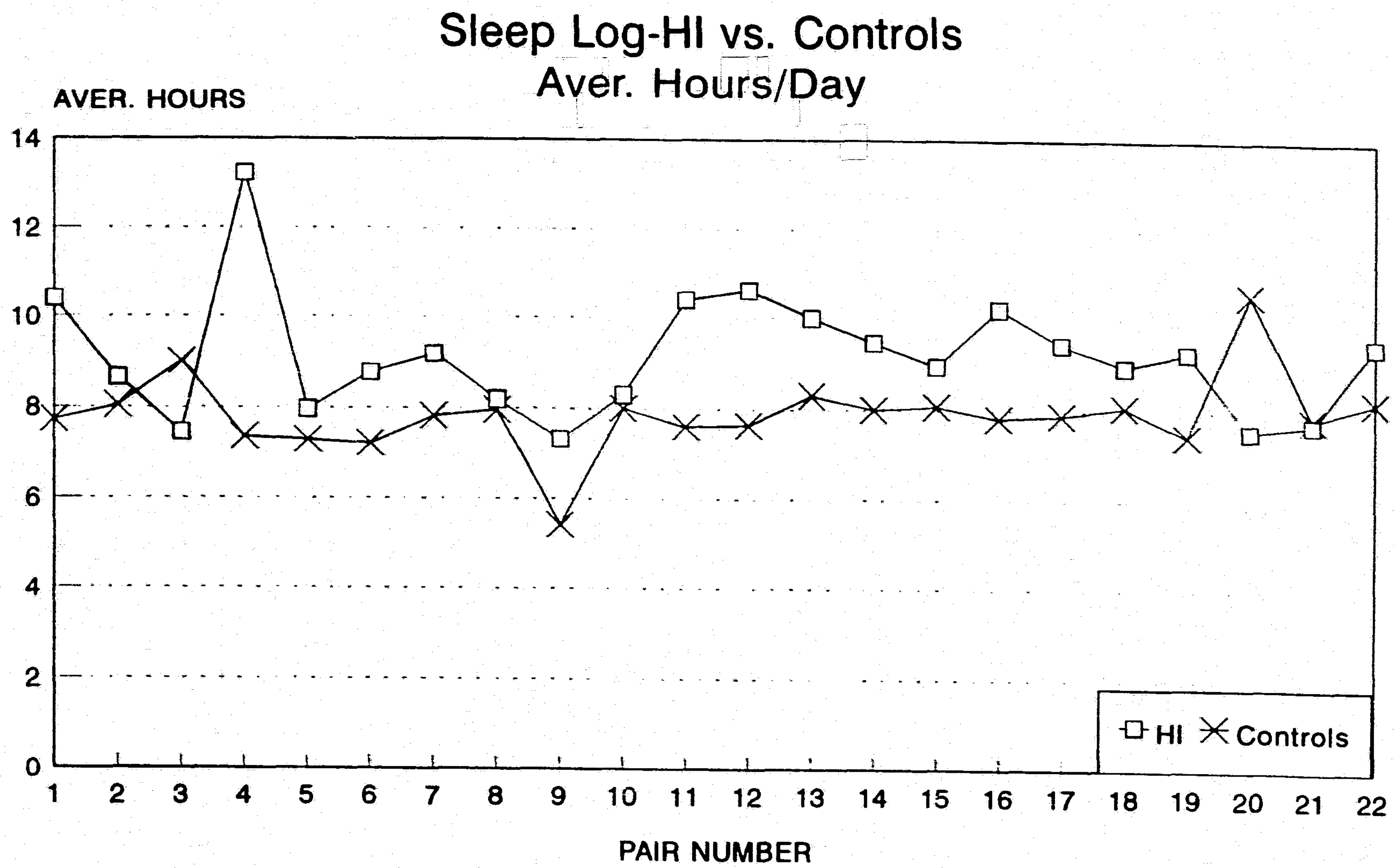


Figure 9. Sleep Log-Average Number of Hours Slept Per Day for CHI Group vs. Control Group.

<u>Minor CHI and Control Group Comparisons</u>

Table 4 contains the comparisons between the Minor CHI group and their matched Controls on all measures. The comparisons on the Alertness Scale and the Sleep Log are based on information from 11 subjects per group. All other comparisons are based on 14 subjects per group. A $\underline{t}$ value and probability estimate for one measure (Sleep Onset task - Duration) could not be calculated due to the lack of variability in the Control group results - i.e., the duration of the task was 30.0 minutes for every Control subject. The difference between the groups on the False Positives score of the Vigilance task was non-significant at the .05 level. The difference between the groups in the average number of hours slept each day (Sleep Log) was significant at the .01 level. All other measures were significantly different between the groups at the .005 level. Figures 10 - 18 illustrate these results in graphic form.

Table 4

Comparisons Between Minor CHI and Control

Groups On All Measures

[Means (M), Standard Deviations (SD), and *t* values]

| Variable | | Group Minor CHI | Control | t |
|---|---|---|---|---|
| Depression Scale | M | 8.93 | 5.14 | 4.22*** |
| | SD | 3.10 | 1.29 | |
| Vitality Scale | M | 16.50 | 9.57 | 7.41*** |
| | SD | 2.88 | 1.99 | |
| Vigilance Task | | | | |
| False Pos. | M | 4.14 | 1.14 | 1.96 ns |
| | SD | 5.20 | 2.41 | |
| Misses | M | 2.50 | 0.07 | 3.45*** |
| | SD | 2.62 | 0.27 | |
| Total Errors | M | 6.64 | 1.21 | 3.00*** |
| | SD | 6.33 | 2.39 | |
| Sleep Onset Task | | | | |
| Touches | M | 9.07 | 0.43 | 4.79*** |
| | SD | 6.66 | 1.09 | |
| Duration | M | 23.26 | 30.00 | NA |
| | SD | 2.18 | 0.00 | |
| Alertness Scale (1) | | | | |
| Average AM | M | 2.52 | 3.38 | -3.99*** |
| | SD | 0.52 | 0.44 | |
| Average PM | M | 2.16 | 3.40 | -5.09*** |
| | SD | 0.66 | 0.48 | |

Table 4 (Cont.)

| Variable | | Group Minor CHI | Control | t |
|---|---|---|---|---|
| Alertness Scale (1) | | | | |
| Total Average | M | 2.34 | 3.37 | -6.60*** |
| | SD | 0.43 | 0.29 | |
| Sleep Log (1) | | | | |
| Average/Day | M | 9.07 | 7.59 | 2.56** |
| (Hours) | SD | 1.72 | 0.87 | |

ns - non-significant
NA - not applicable
*p <.05; **p <.01; ***p <.005

NOTE: Estimated probabilities computed using the Randomization Test for Scores, 2000 permutations considered, 2 - tailed.

(1) Alertness Scale and Sleep Log comparisons are based on 11 subjects per group; all other measures have 14 subjects per group.

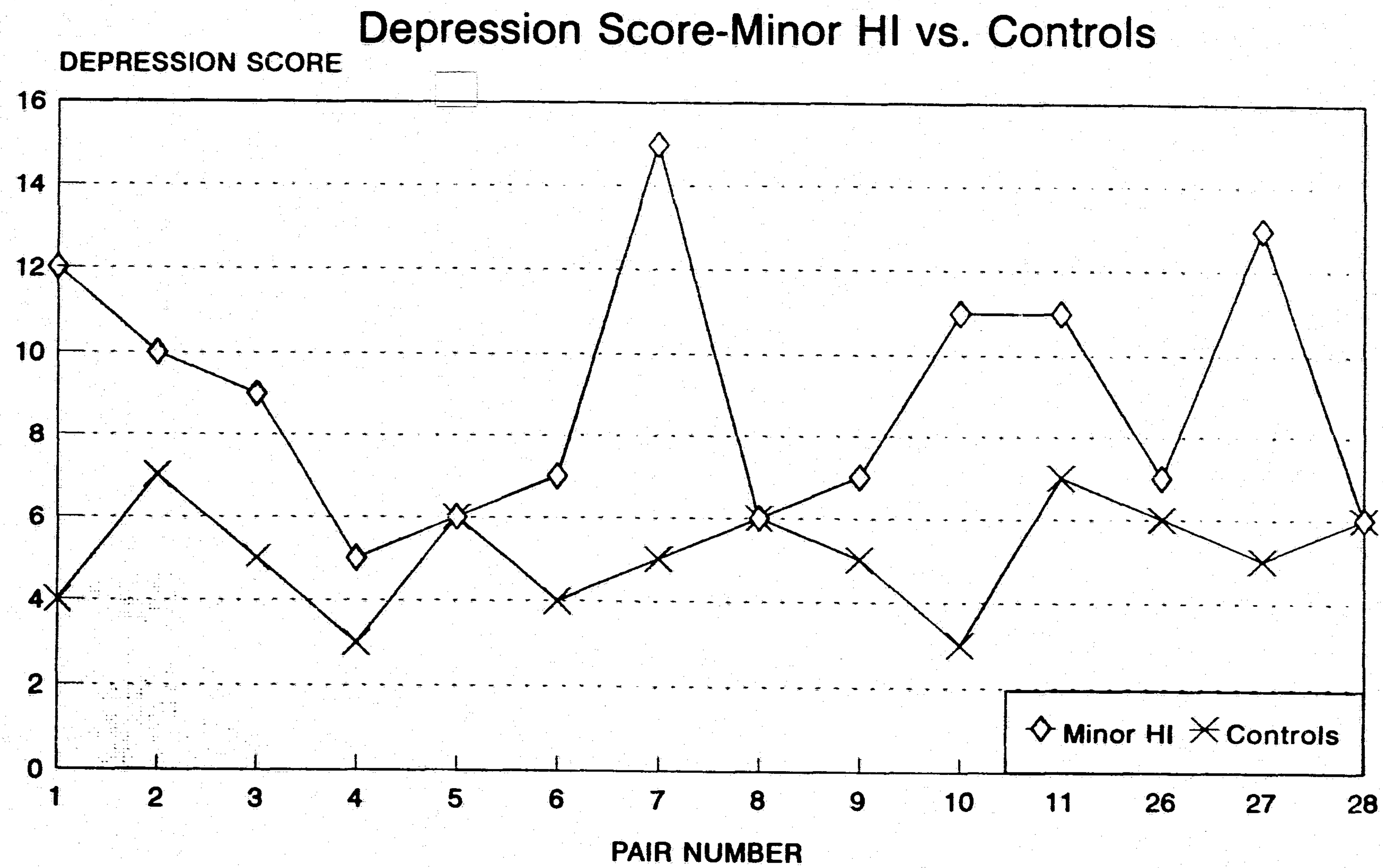


Figure 10. Depression Score for Minor CHI Group vs. Control Group.

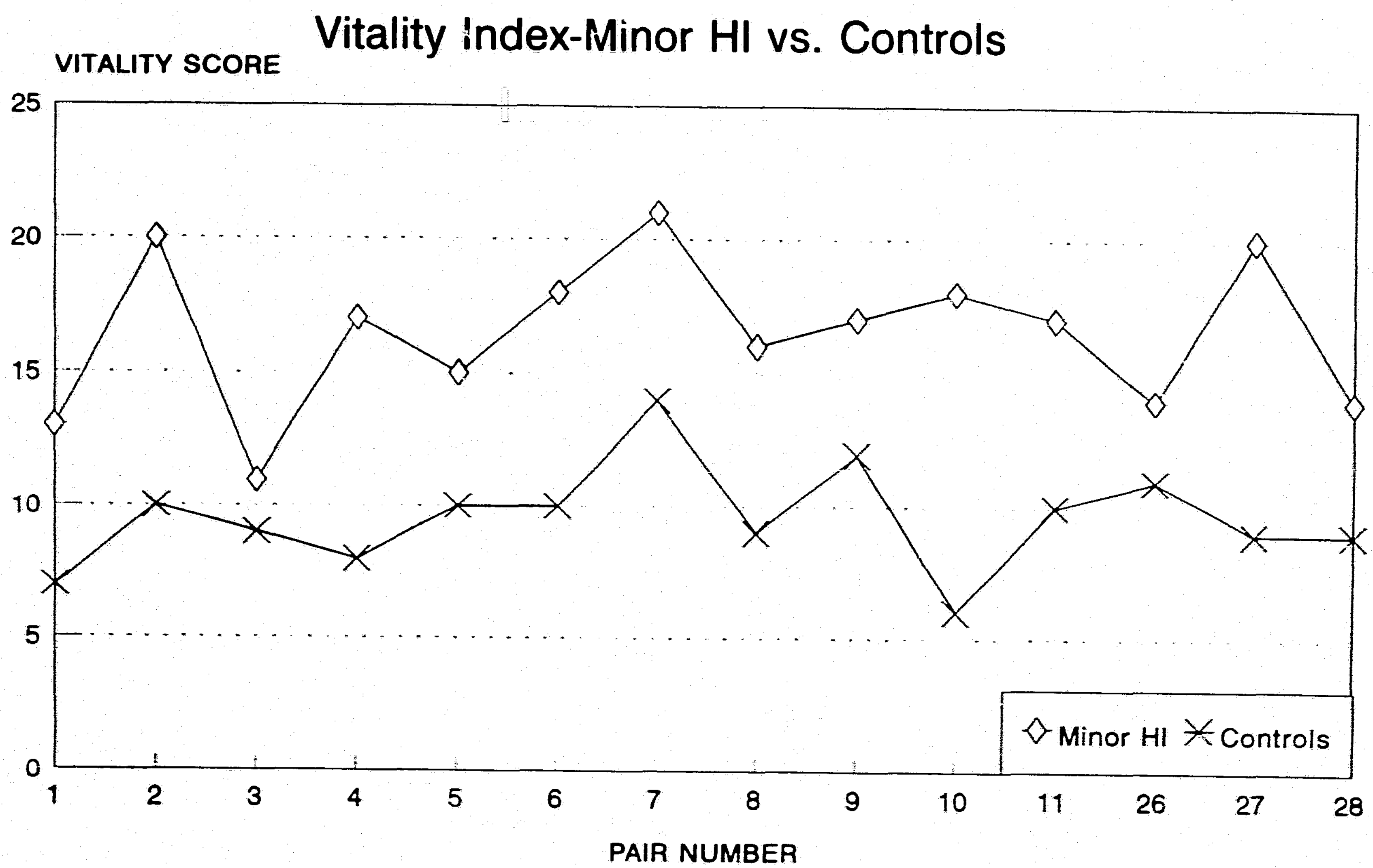


Figure 11. Vitality Index Scores for Minor CHI Group vs. Control Group.

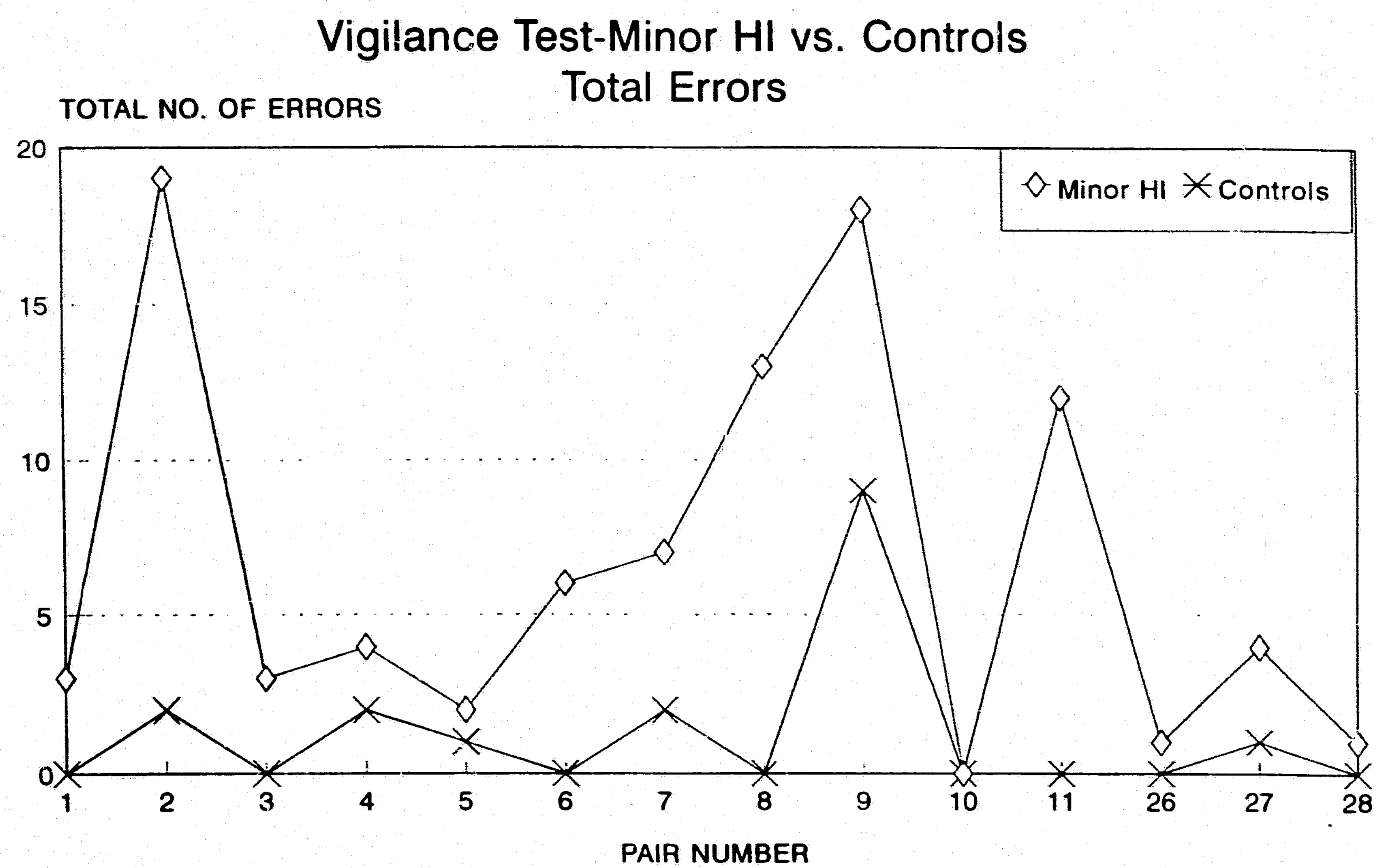


Figure 12. Vigilance Task-Total Number of Errors for Minor CHI Group vs. Control Group.

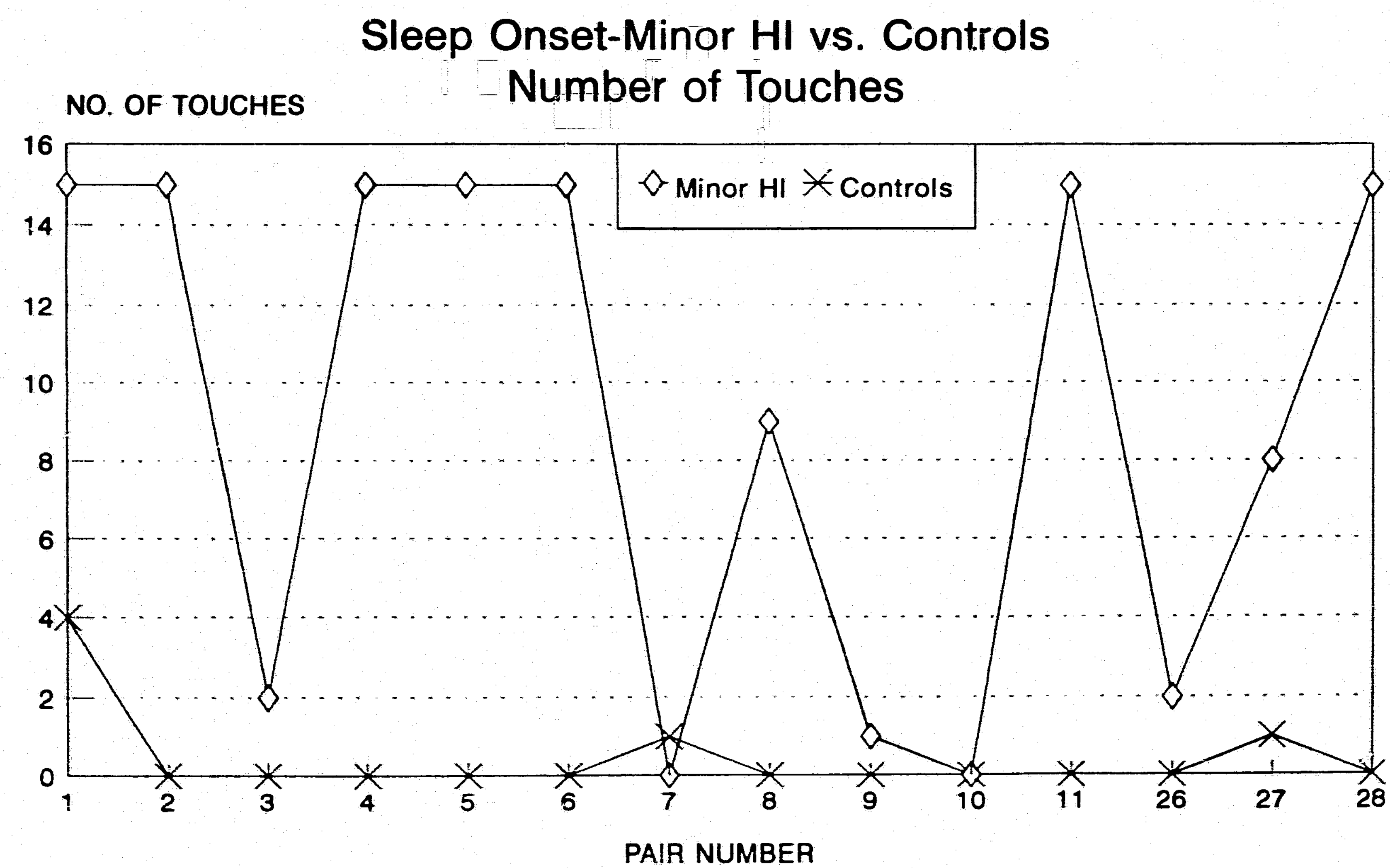


Figure 13. Sleep Onset Task-Number of Touches for Minor CHI Group vs. Control Group.

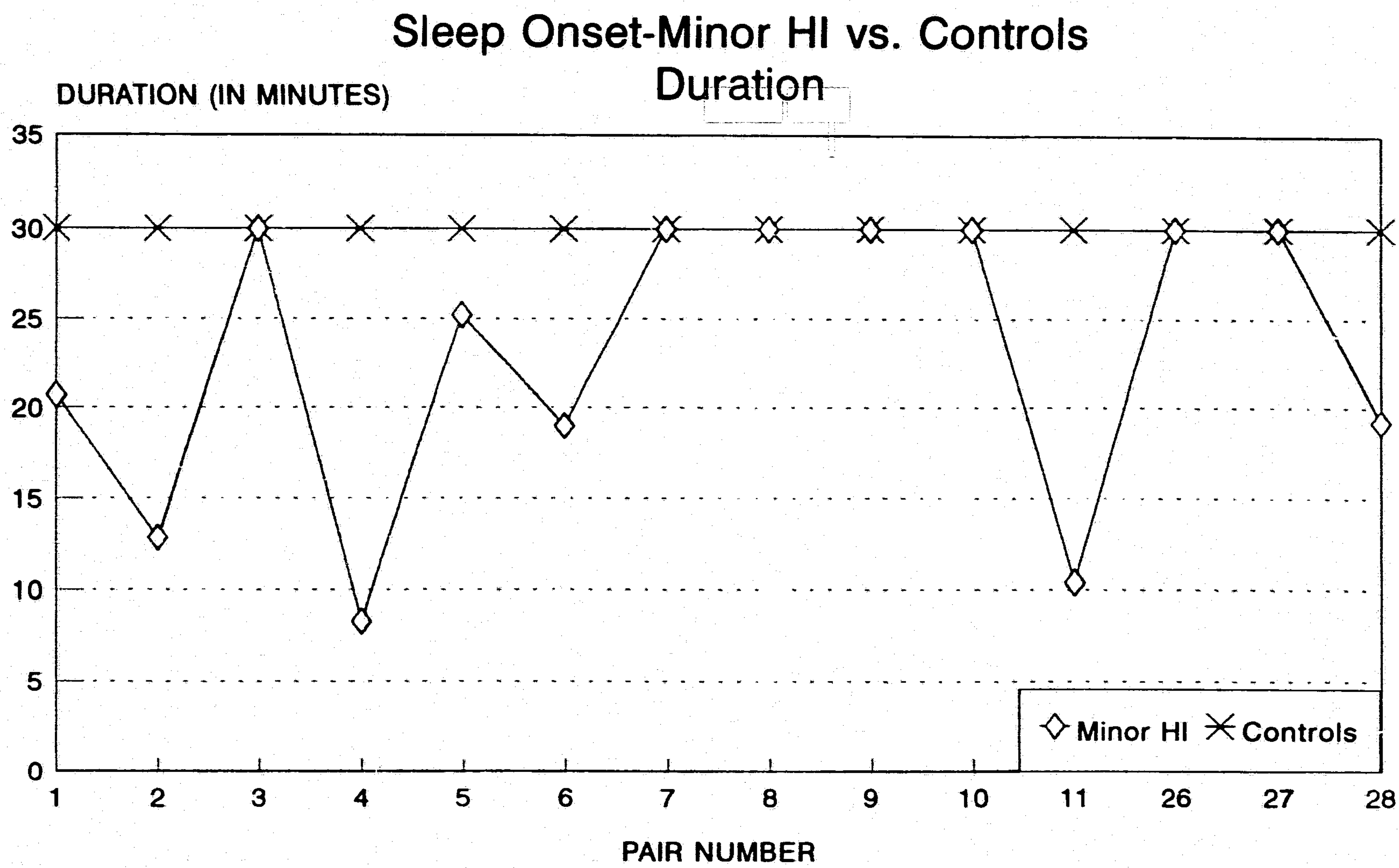

Figure 14. Sleep Onset Task-Duration for Minor CHI Group vs. Control Group.

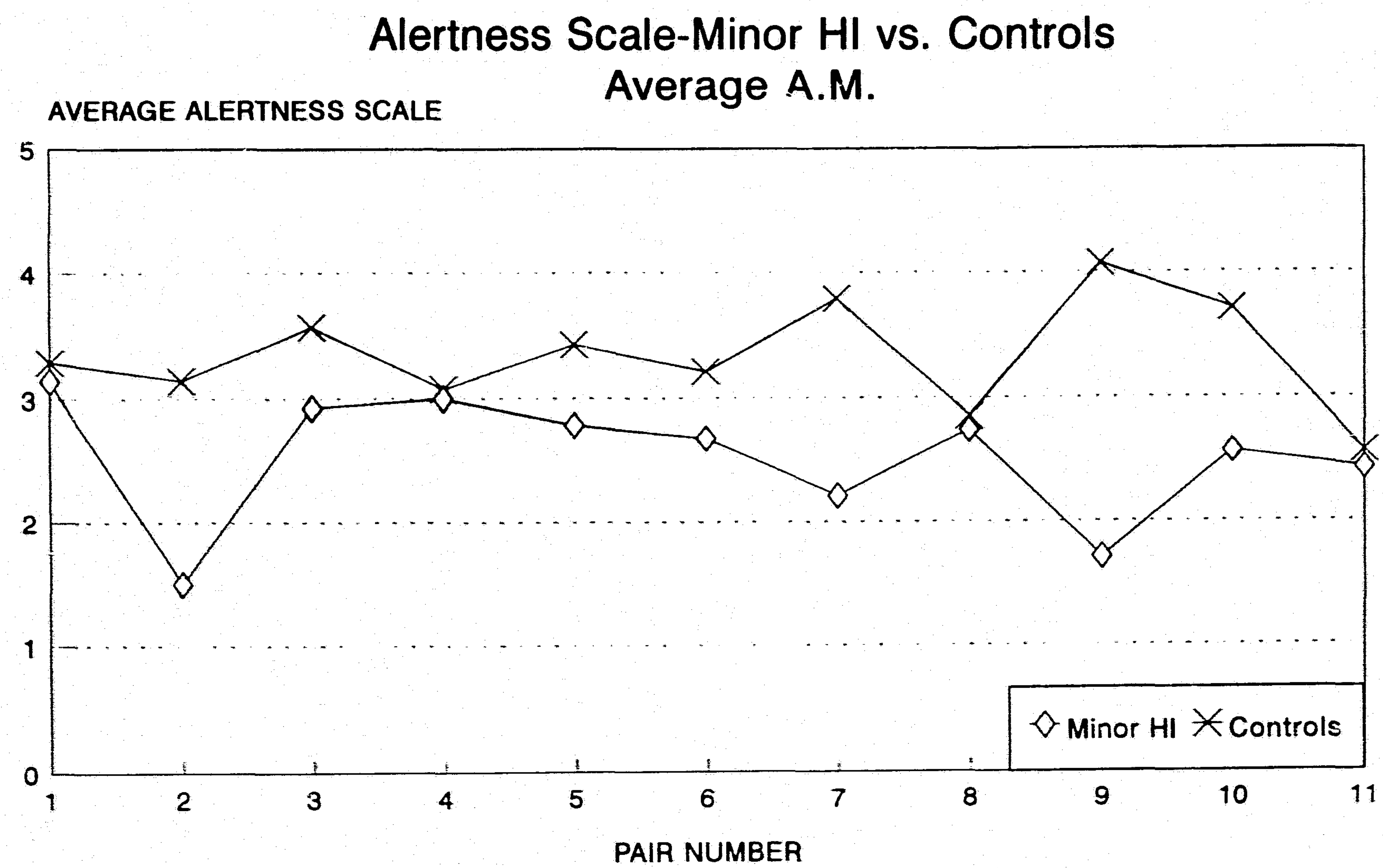


Figure 15. Alertness Scale-Average A.M. for Minor CHI Group vs. Control Group.

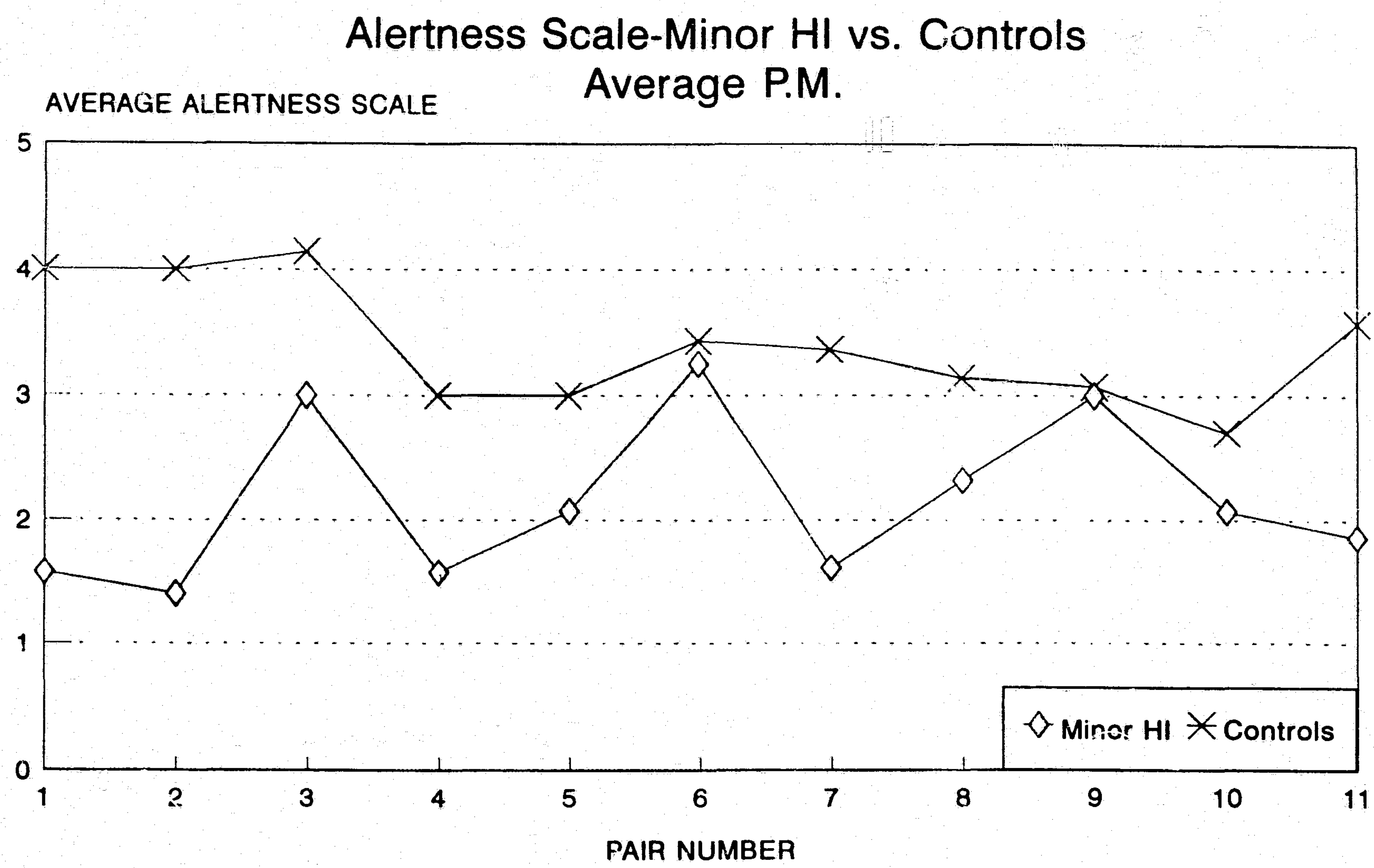


Figure 16. Alertness Scale-Average P.M. For Minor CHI Group vs. Control Group.

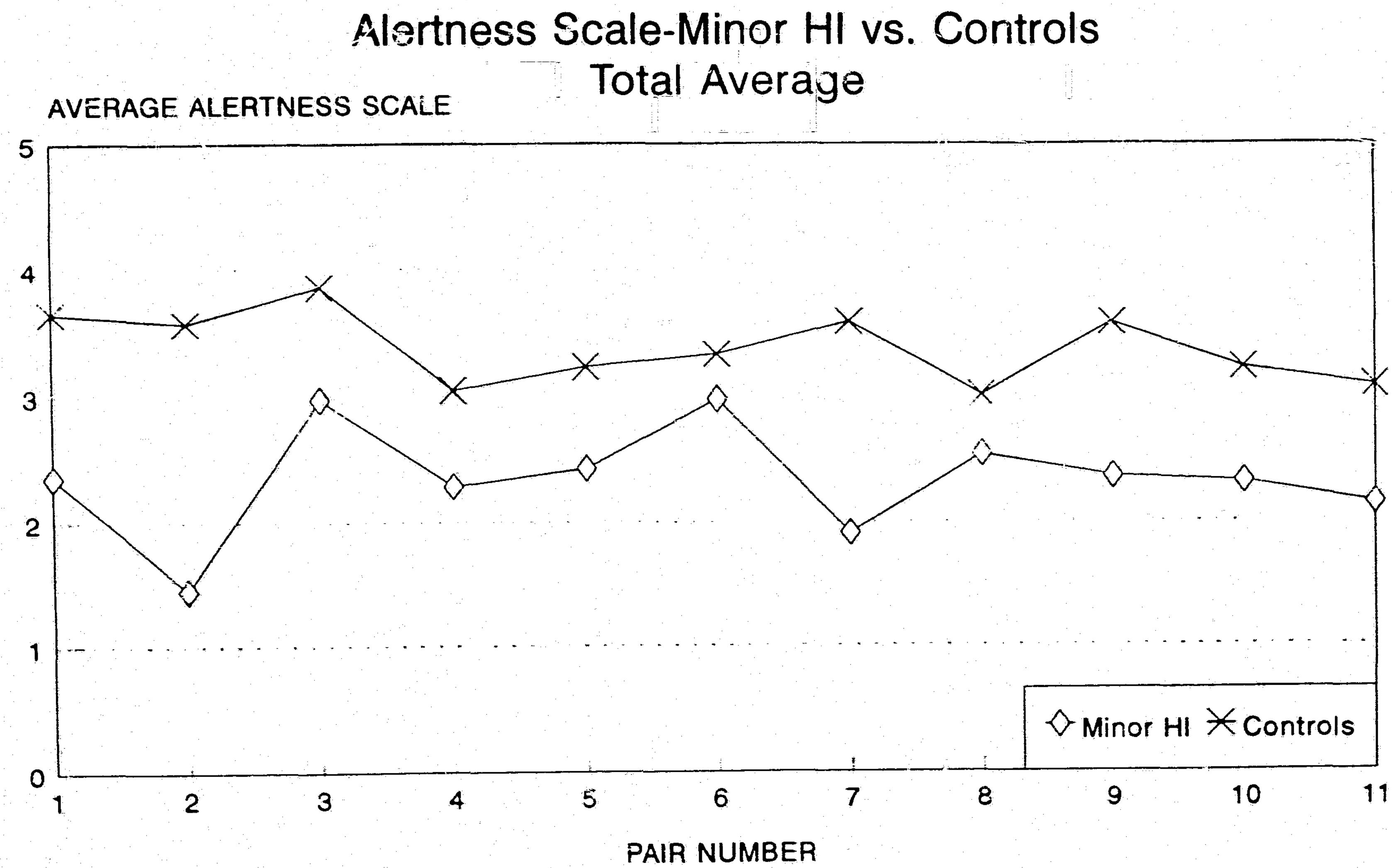


Figure 17. Alertness Scale-Total Average for Minor CHI Group vs. Control Group.

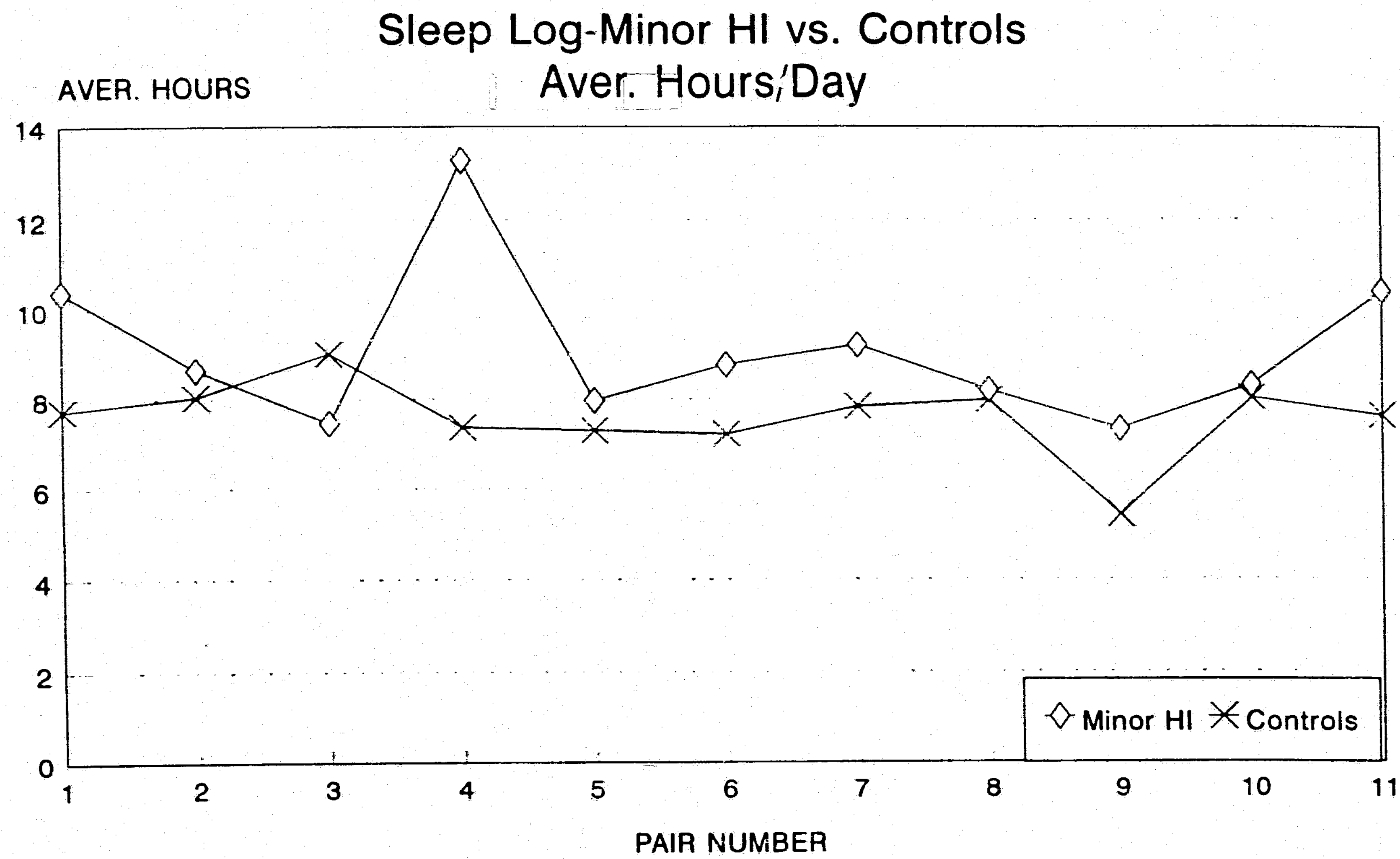


Figure 18. Sleep Log-Average Number of Hours Slept Per Day for Minor CHI Group vs. Control Group.

<u>Severe CHI and Control Group Comparisons</u>

Table 5 contains the results of comparisons between the Severe CHI group and their matched Control group on all measures. The Alertness Scale and Sleep Log results are based on information from 11 subjects per group. All other measures are based on information from 14 subjects per group. Non-significant differences were found between the groups on the Vigilance task (False Positives, Missed Targets, and Total Errors), on the duration of the Sleep Onset task, and on the average AM measure of the Alertness Scale. The differences between the groups on the Number of Touches measure of the Sleep Onset task and on the average number of hours slept per day according to the Sleep Logs were significant at the .05 level. The results of the Depression Scale showed a significant difference between the groups at the .01 level. When the results on the Vitality Scale, the average PM score on the Alertness Scale, and the total average score on the Alertness Scale were analyzed, the differences between the groups were found to be significant at the .005 level. The graphs for these comparisons can be found in Figures 19 - 27.

Table 5

Comparisons Between Severe CHI and Control Groups On All Measures

[Means (M), Standard Deviations (SD), and *t* values]

| Variable | | Group Severe CHI | Control | t |
|---|---|---|---|---|
| Depression Scale | M | 8.79 | 5.43 | 2.98** |
| | SD | 2.97 | 3.01 | |
| Vitality Scale | M | 15.64 | 11.00 | 4.84*** |
| | SD | 2.79 | 2.25 | |
| Vigilance Task | | | | |
| False Pos. | M | 3.14 | 1.29 | 1.56 ns |
| | SD | 4.01 | 1.82 | |
| Misses | M | 1.21 | 0.64 | 1.29 ns |
| | SD | 1.31 | 1.01 | |
| Total Errors | M | 4.36 | 1.93 | 1.94 ns |
| | SD | 3.99 | 2.43 | |
| Sleep Onset Task | | | | |
| Touches | M | 8.64 | 4.21 | 2.19* |
| | SD | 6.31 | 4.21 | |
| Duration | M | 25.03 | 29.19 | -1.68 ns |
| | SD | 8.75 | 3.05 | |
| Alertness Scale (1) | | | | |
| Average AM | M | 2.77 | 2.95 | -0.90 ns |
| | SD | 0.40 | 0.53 | |
| Average PM | M | 2.40 | 3.44 | -5.46*** |
| | SD | 0.40 | 0.49 | |

Table 5 (Cont)

| Variable | | Group Severe CHI | Control | t |
|---|---|---|---|---|
| Alertness Scale (1) | | | | |
| Total Average | M | 2.59 | 3.19 | -4.33*** |
| | SD | 0.35 | 0.30 | |
| Sleep Log (1) | | | | |
| Average/Day | M | 9.23 | 8.16 | 2.81* |
| (Hours) | SD | 0.95 | 0.83 | |

ns - non-significant
*p <.05; **p <.01; ***p <.005

NOTE: Estimated probabilities computed using the Randomization Test for Scores, 2000 permutations considered, 2 tailed.

(1) Alertness Scale and Sleep Log comparisons are based on 11 subjects per group; all other measures have 14 subjects per group.

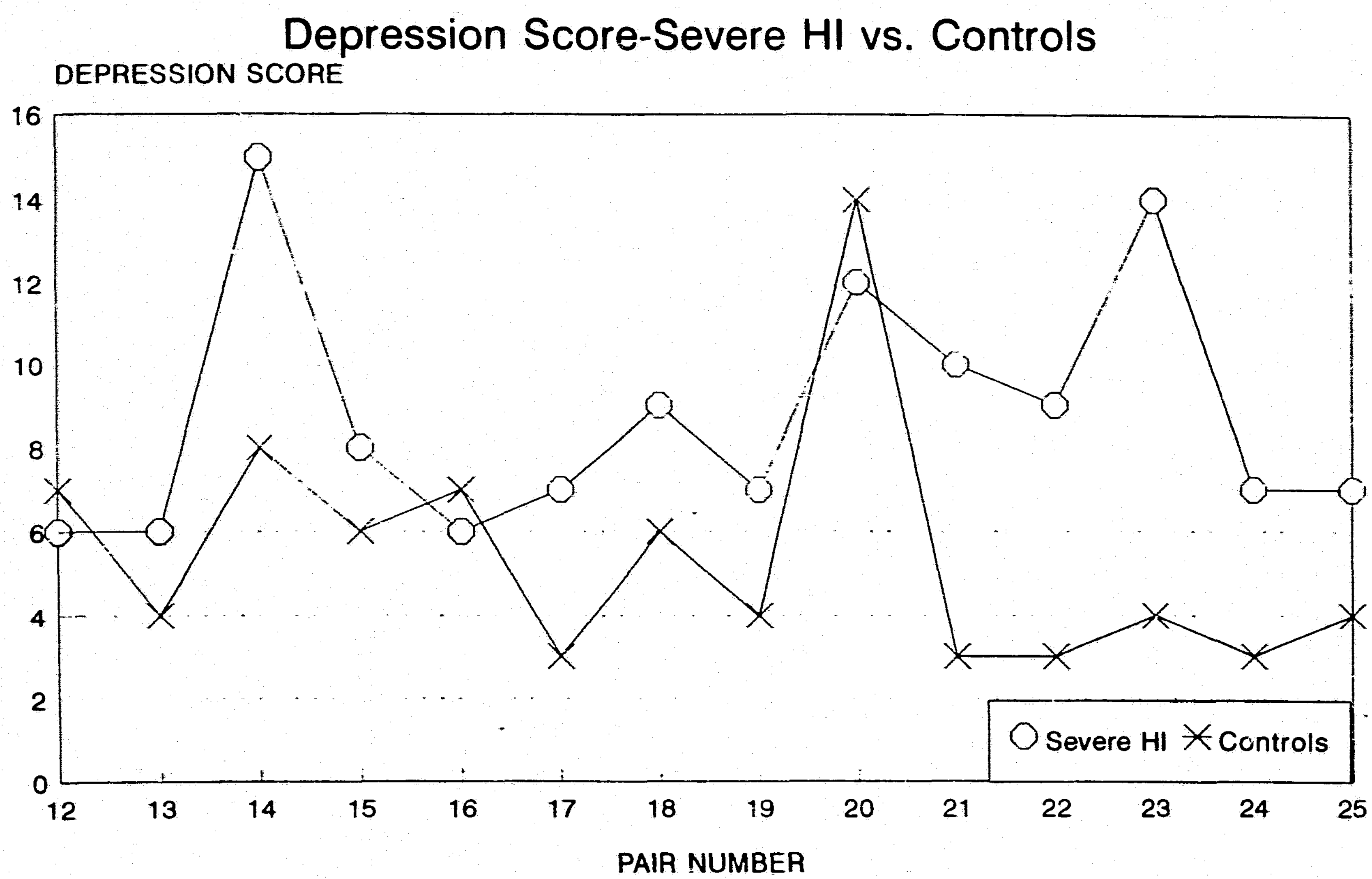


Figure 19. Depression Score for Severe CHI Group vs. Control Group.

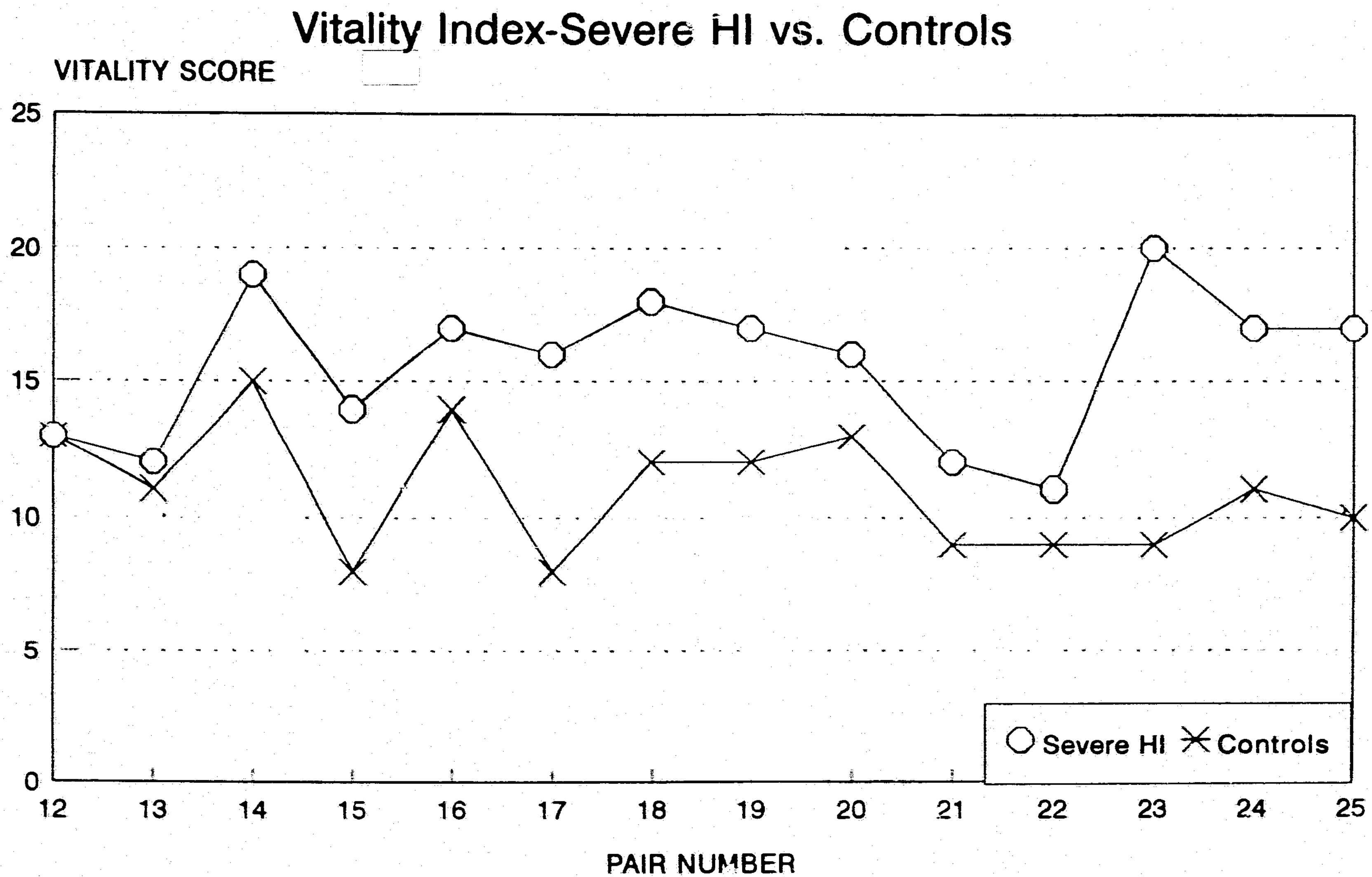


Figure 20. Vitality Index Scores for Severe CHI Group vs. Control Group.

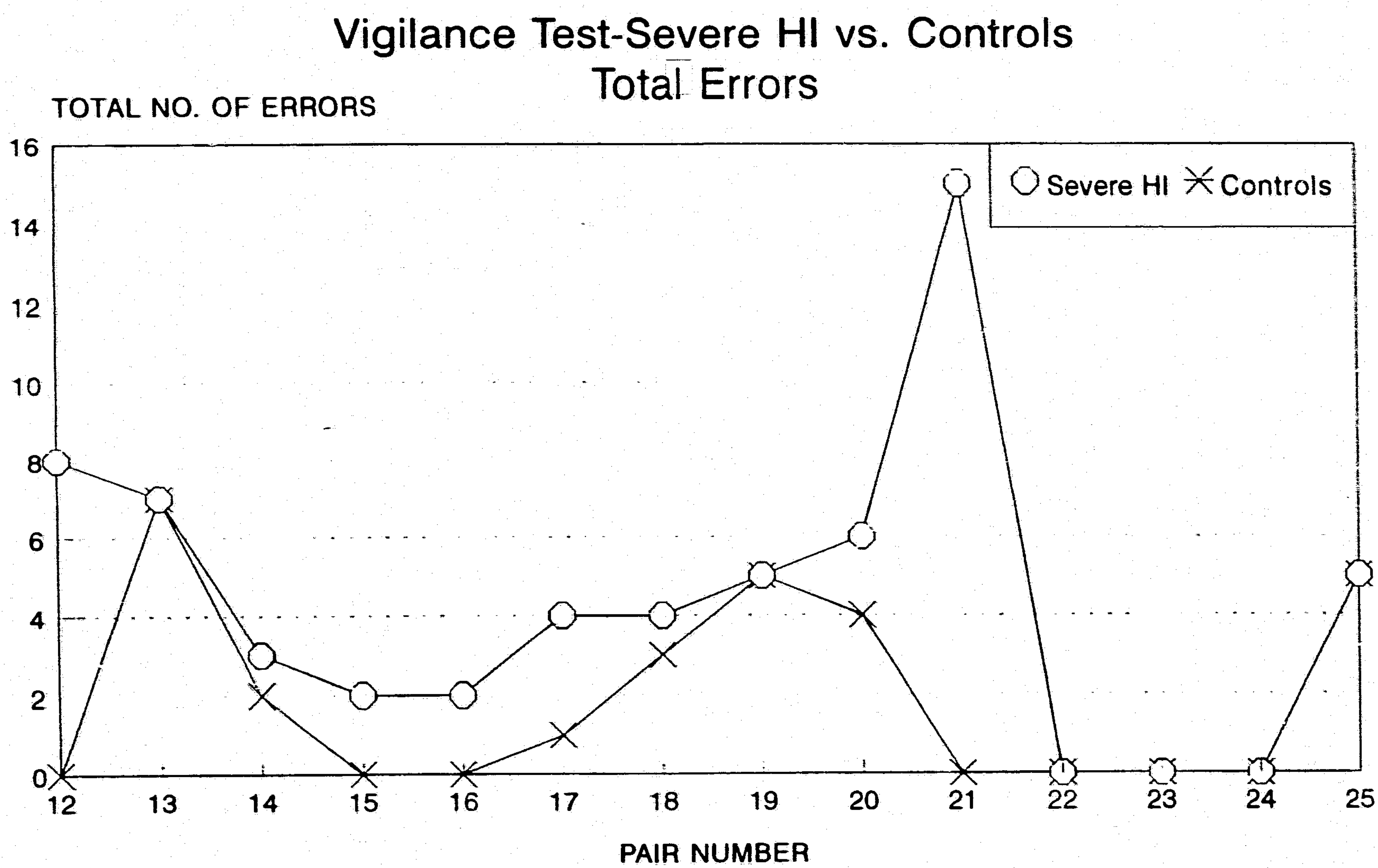


Figure 21. Vigilance Task-Total Number of Errors for Severe CHI Group vs. Control Group.

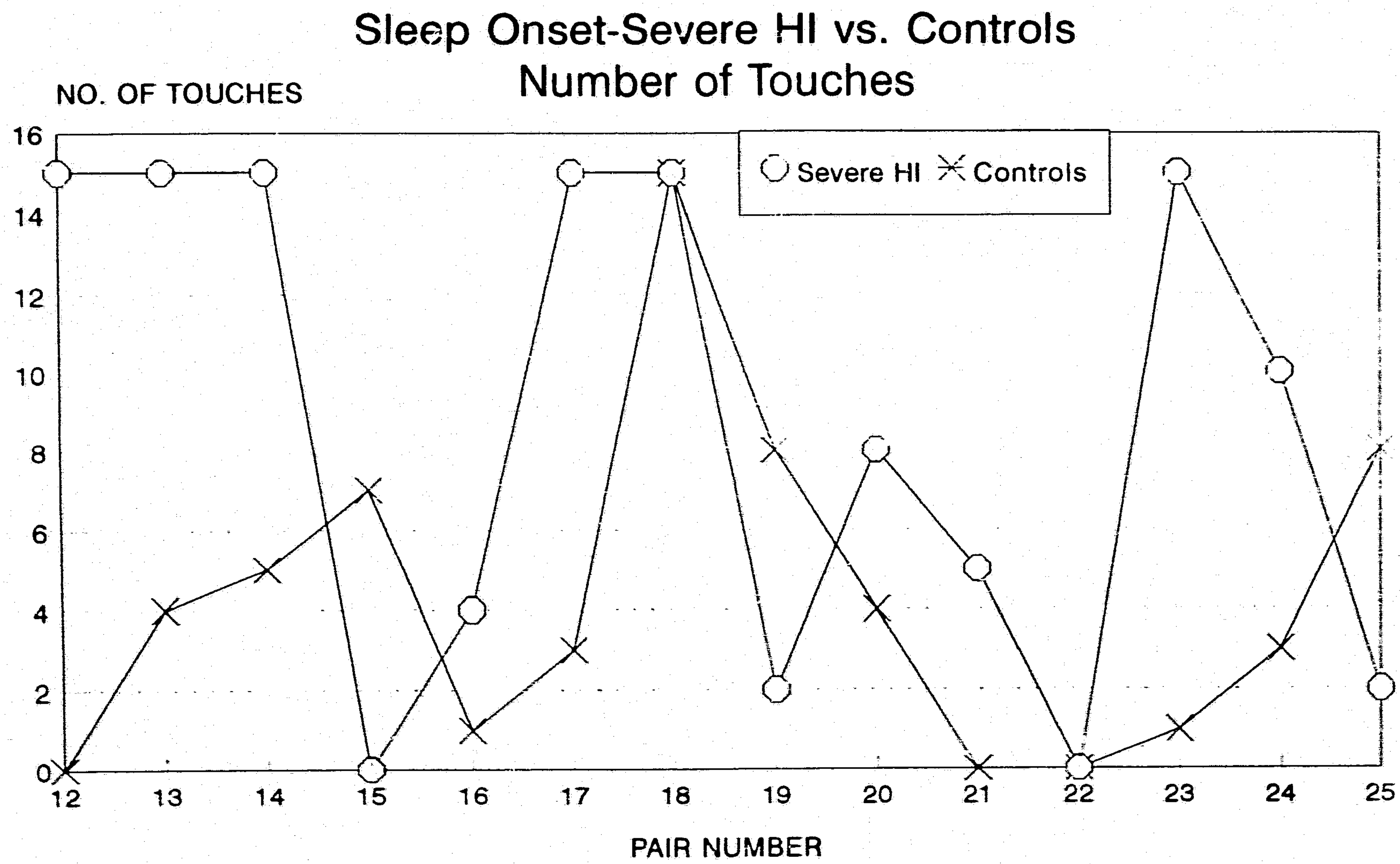


Figure 22. Sleep Onset Task-Number of Touches for Severe CHI Group vs. Control Group.

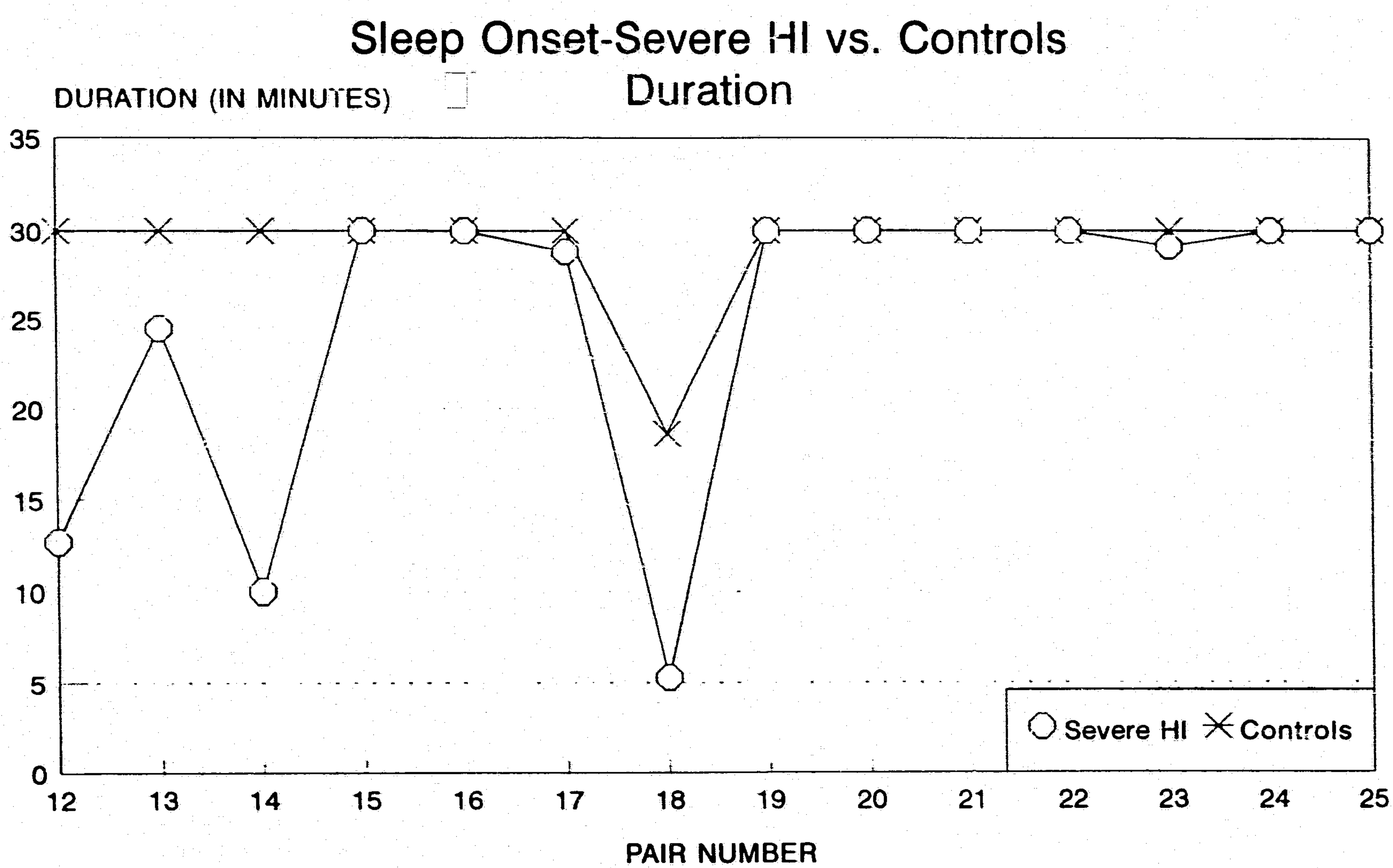


Figure 23. Sleep Onset Task-Duration for Severe CHI Group vs. Control Group.

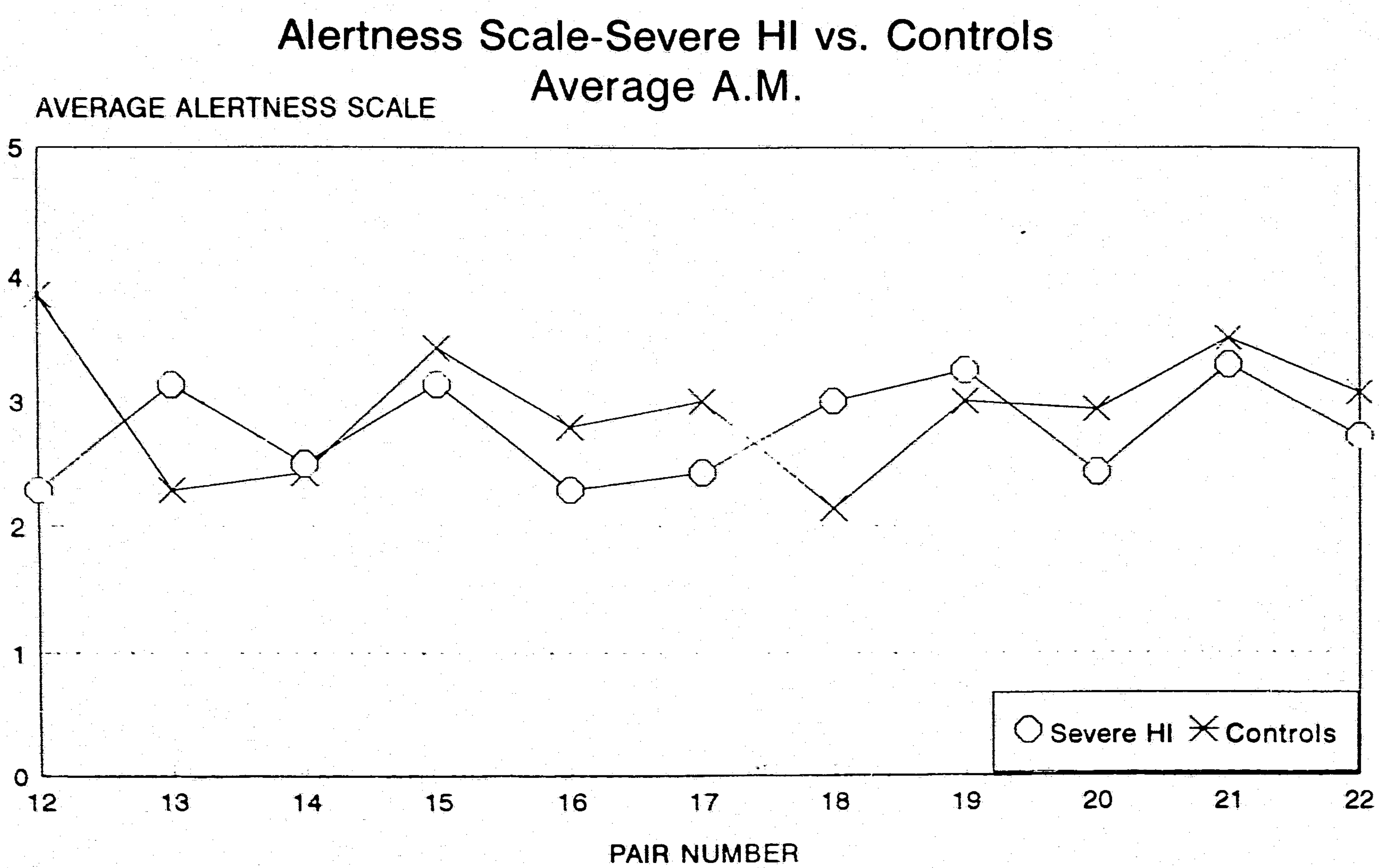


Figure 24. Alertness Scale-Average A.M. for Severe CHI Group vs. Control Group.

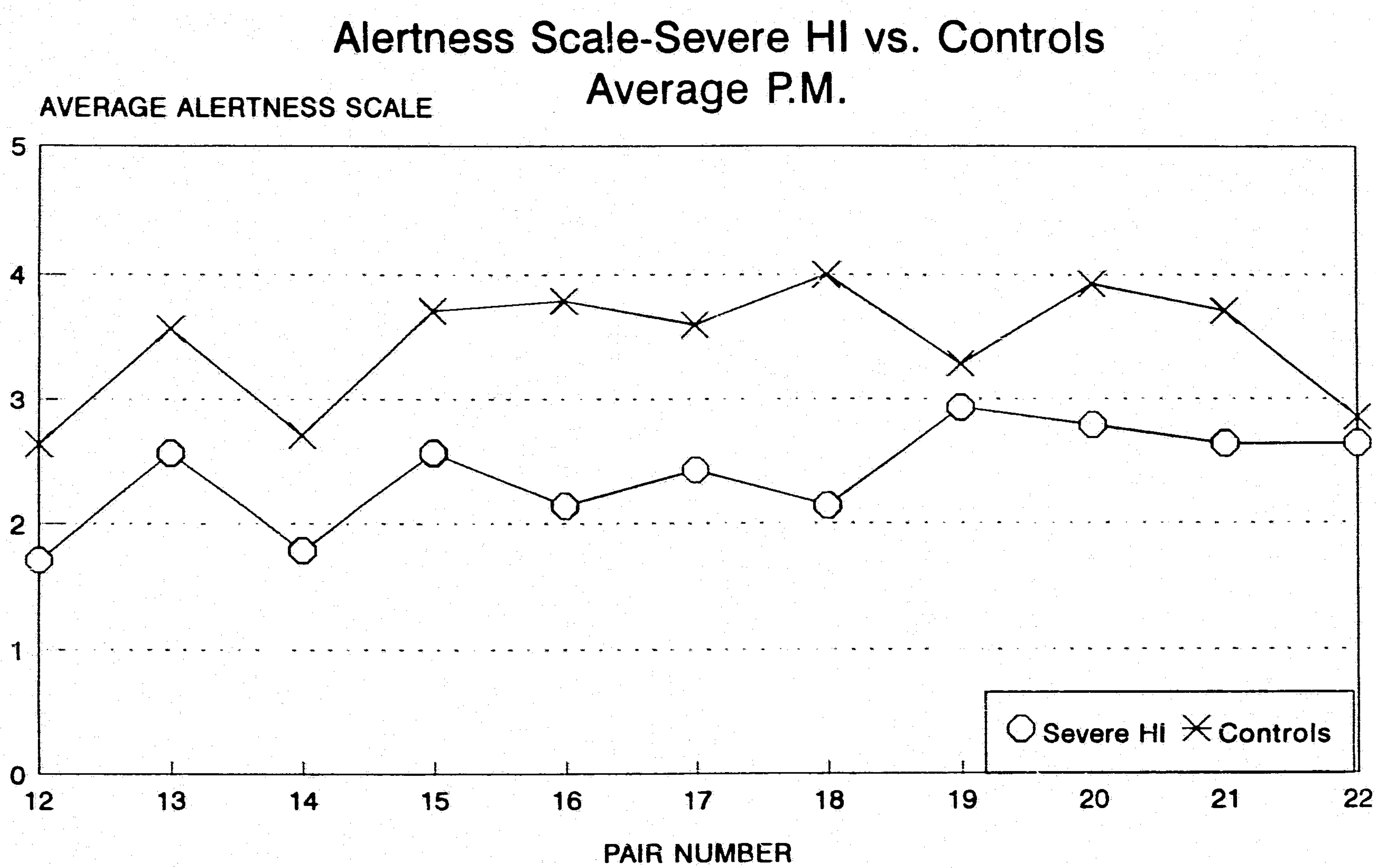


Figure 25. Alertness Scale-Average P.M. for Severe CHI Group vs. Control Group.

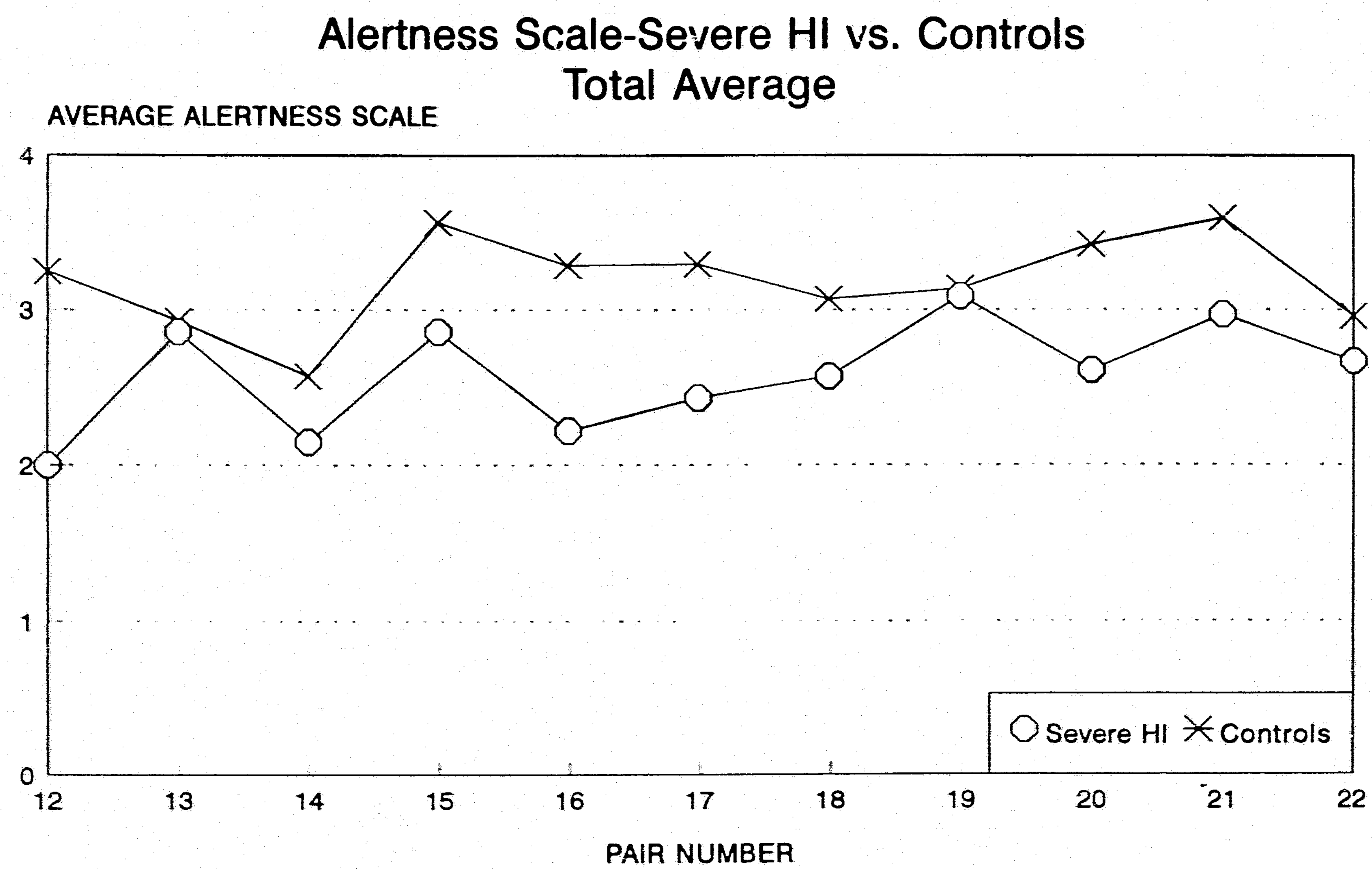


Figure 26. Alertness Scale-Total Average for Severe CHI Group vs. Control Group.

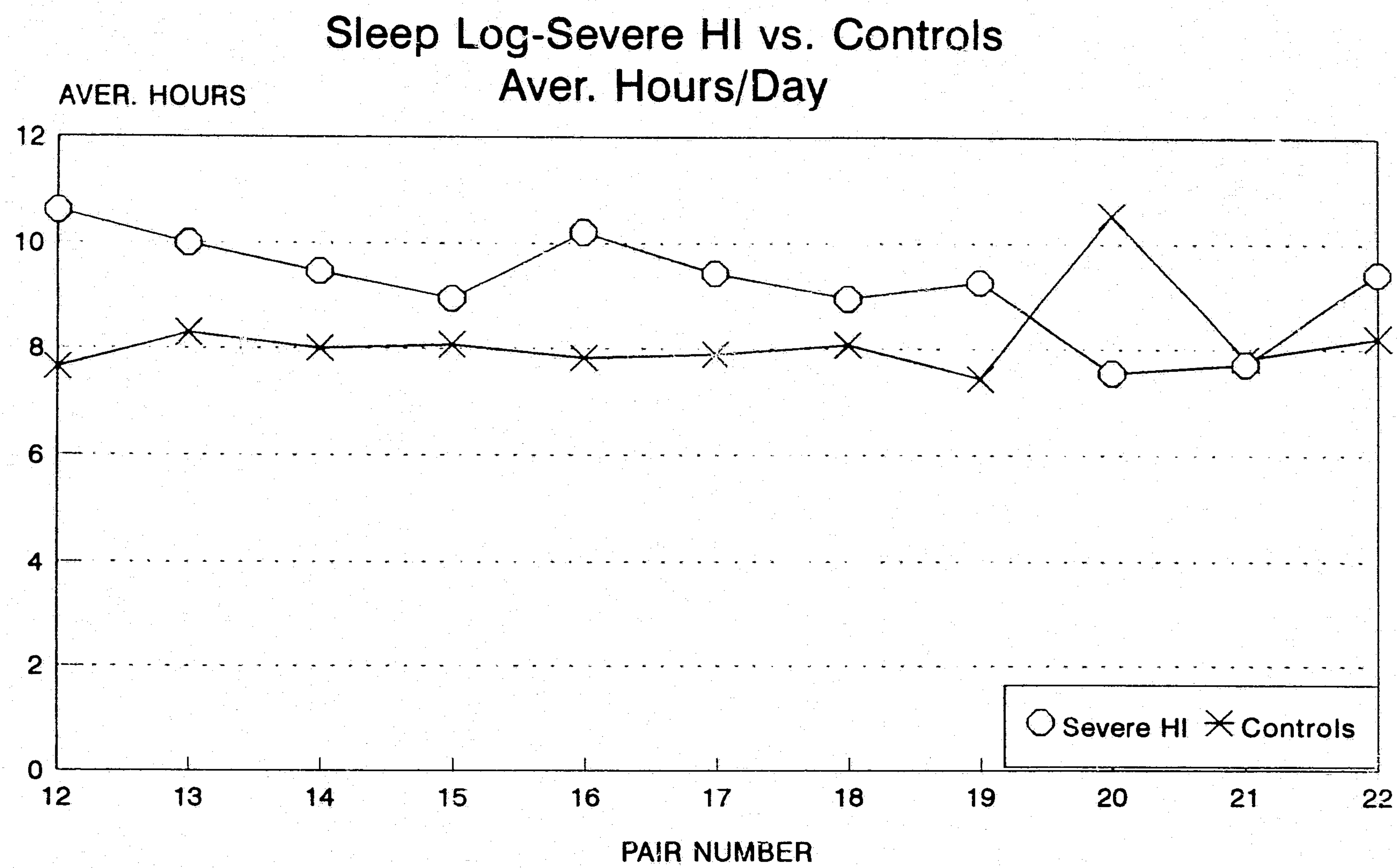


Figure 27. Sleep Log-Average Number of Hours Slept Per Day for Severe CHI Group vs. Control Group.

Minor CHI and Severe CHI Group Comparisons

Table 6 contains the results for comparisons between the two CHI subgroups. No significant differences were found on any of the measures. Figures 28 - 36 contain the relevant graphs.

Table 6

Comparisons Between Minor CHI and Severe CHI Groups

On All Measures

[Means (M), Standard Deviations (SD), and *t* values]

| Variable | | Group: Minor CHI | Severe CHI | *t* |
|---|---|---|---|---|
| Depression | M | 8.93 | 8.79 | 0.13 ns |
| Scale | SD | 3.10 | 2.97 | |
| Vitality | M | 16.50 | 15.64 | 0.80 ns |
| Scale | SD | 2.88 | 2.79 | |
| Vigilance Task | | | | |
| False Pos. | M | 4.14 | 3.14 | 0.57 ns |
| | SD | 5.20 | 4.06 | |
| Misses | M | 2.50 | 1.21 | 1.64 ns |
| | SD | 2.62 | 1.31 | |
| Total Errors | M | 6.64 | 4.36 | 1.14 ns |
| | SD | 6.33 | 3.99 | |
| Sleep Onset Task | | | | |
| Touches | M | 9.07 | 8.64 | 0.18 ns |
| | SD | 6.66 | 6.31 | |
| Duration | M | 23.26 | 25.03 | -0.56 ns |
| | SD | 8.14 | 8.75 | |
| Alertness Scale (1) | | | | |
| Average AM | M | 2.52 | 2.77 | -1.26 ns |
| | SD | 0.52 | 0.40 | |
| Average PM | M | 2.16 | 2.40 | -1.[illegible]3 ns |
| | SD | 0.66 | 0.40 | |

Table 6 (Cont)

| Variable | | Group Minor CHI | Severe CHI | t |
|---|---|---|---|---|
| Alertness Scale (1) | | | | |
| Total Average | M | 2.34 | 2.59 | -1.45 ns |
| | SD | 0.43 | 0.35 | |
| Sleep Log (1) | | | | |
| Average/Day | M | 9.07 | 9.23 | -0.26 ns |
| (Hours) | SD | 1.72 | 0.95 | |

ns - non-significant
*p <.05; **p <.01; ***p <.005

NOTE: Estimated probabilities computed using the Randomization Test for Scores, 2000 permutations considered, 2 - tailed.

(1) Alertness Scale and Sleep Log comparisons are based on 11 subjects per group; all other measures have 14 subjects per group.

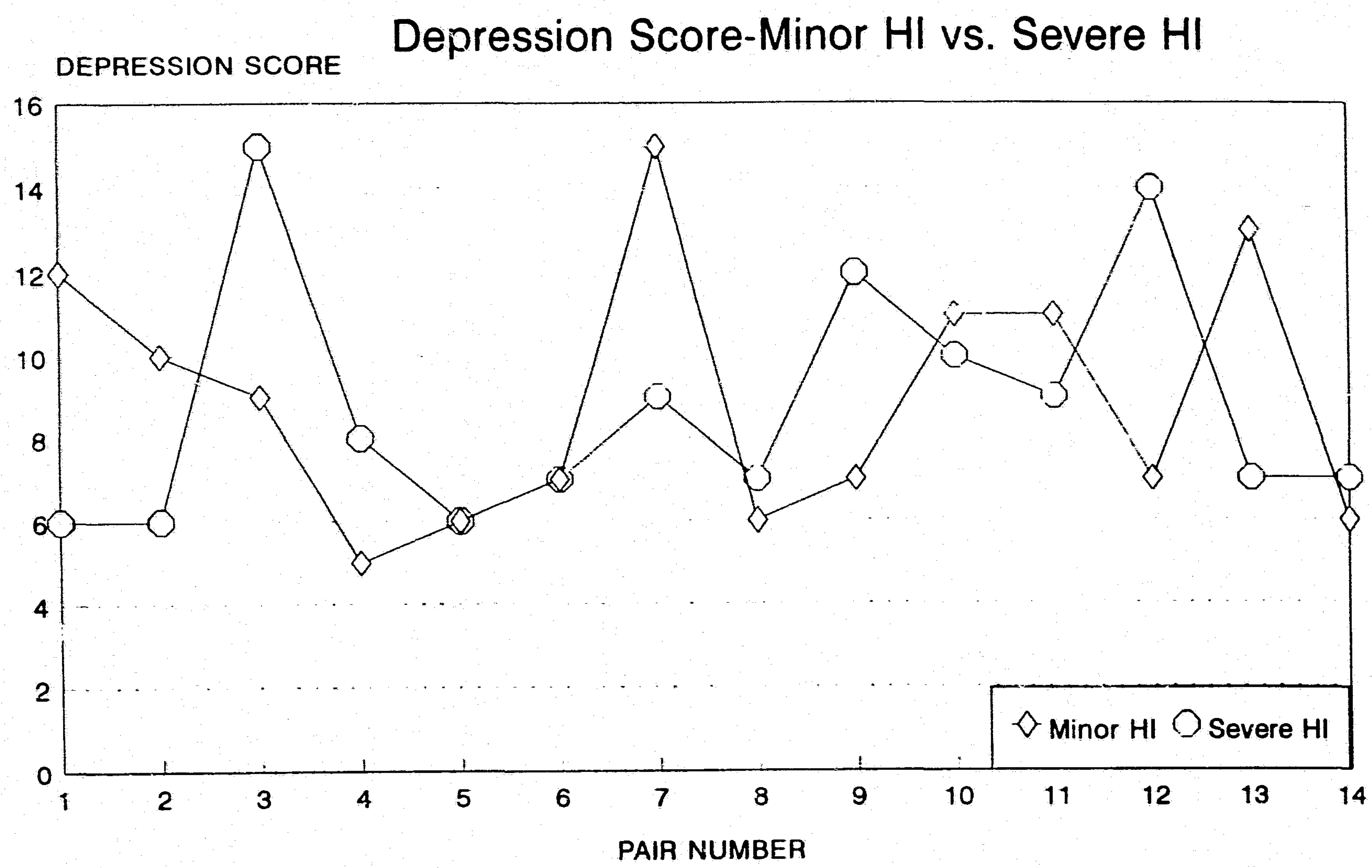


Figure 28. Depression Score for Minor CHI Group vs. Severe CHI Group.

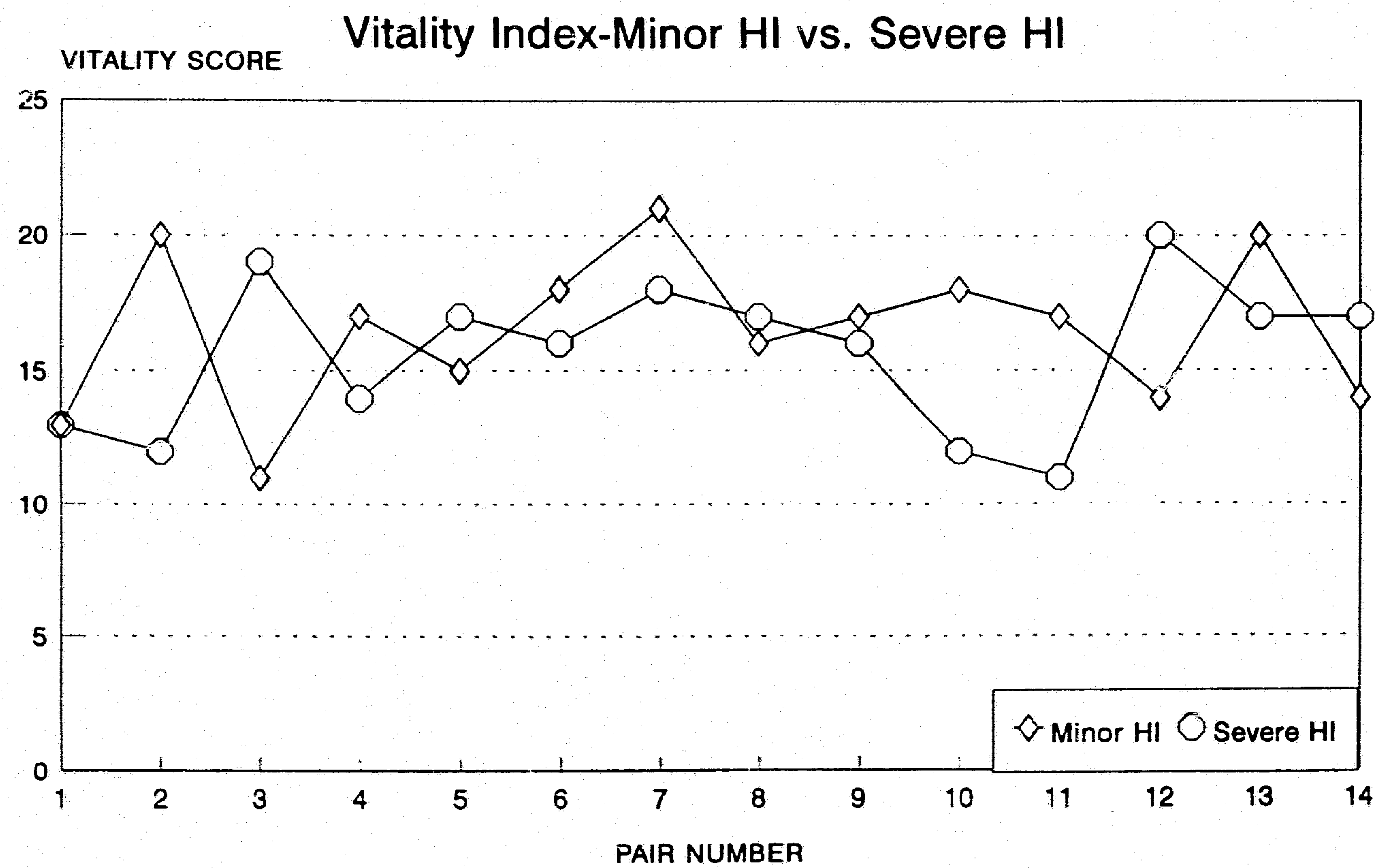


Figure 29. Vitality Index Scores for Minor CHI Group vs. Severe CHI Group.

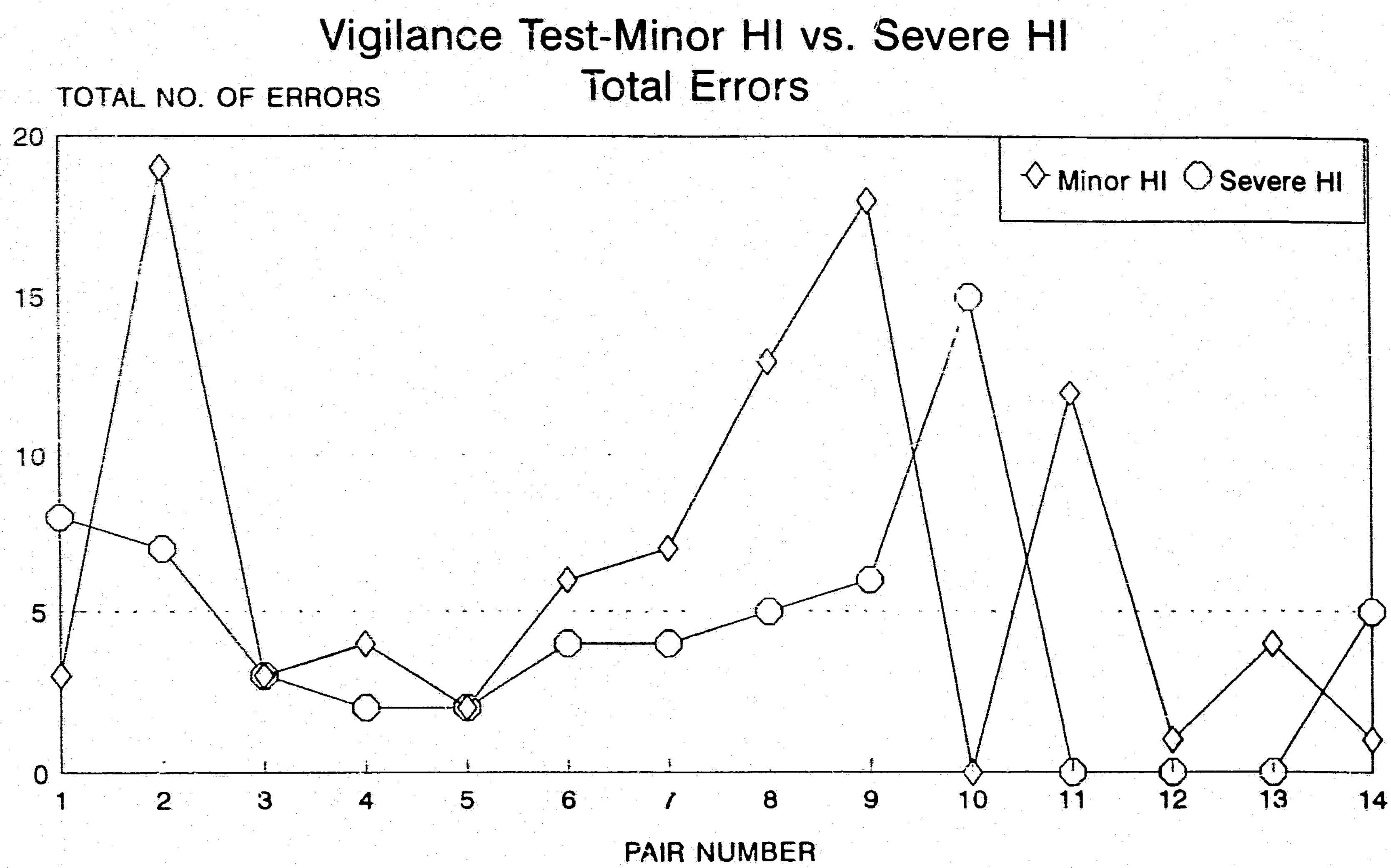


Figure 30. Vigilance Test-Total Number of Errors for Minor CHI Group vs. Severe CHI Group.

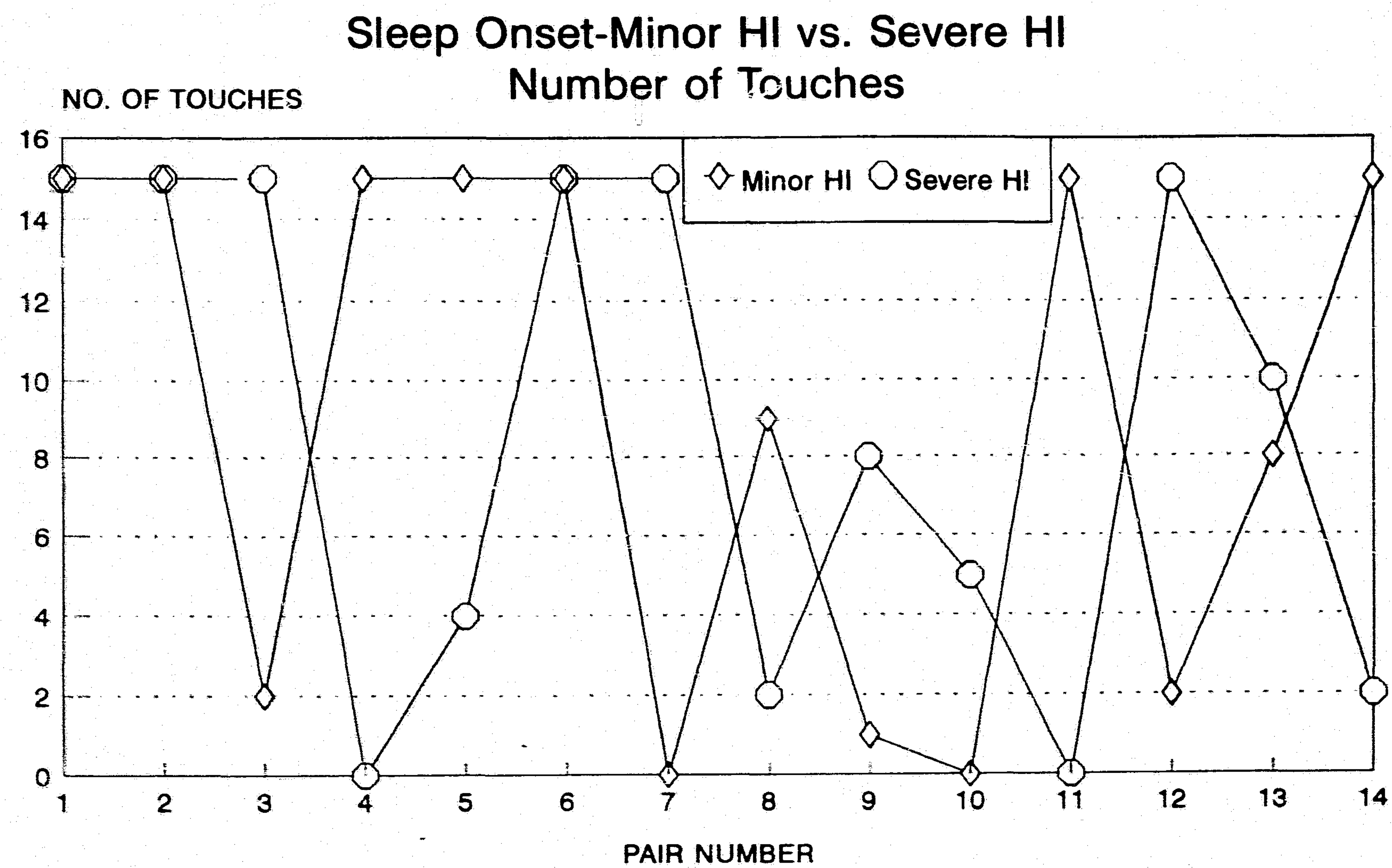


Figure 31. Sleep Onset Task-Number of Touches for Minor CHI Group vs. Severe CHI Group.

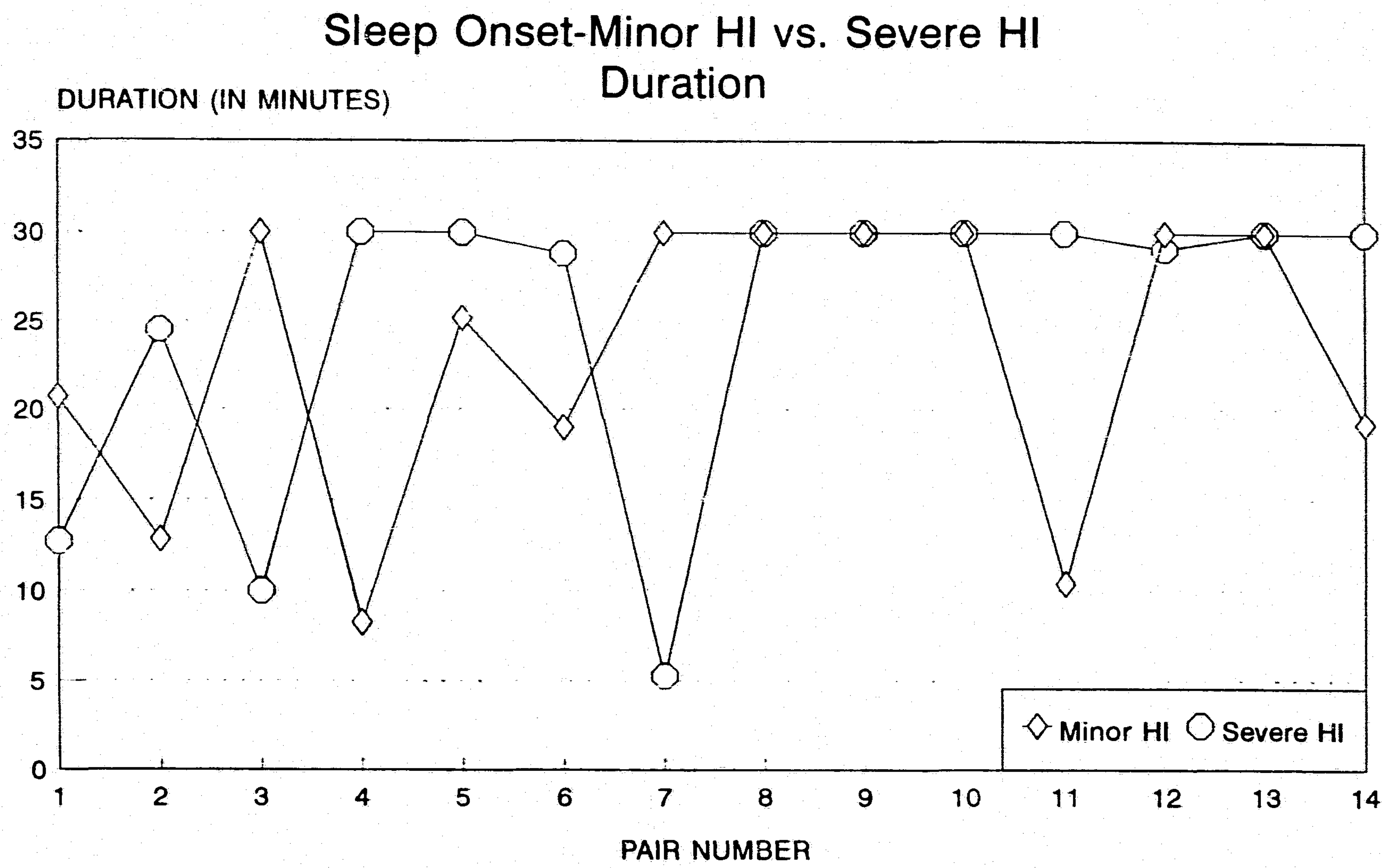


Figure 32. Sleep Onset Task-Duration for Minor CHI Group vs. Severe CHI Group.

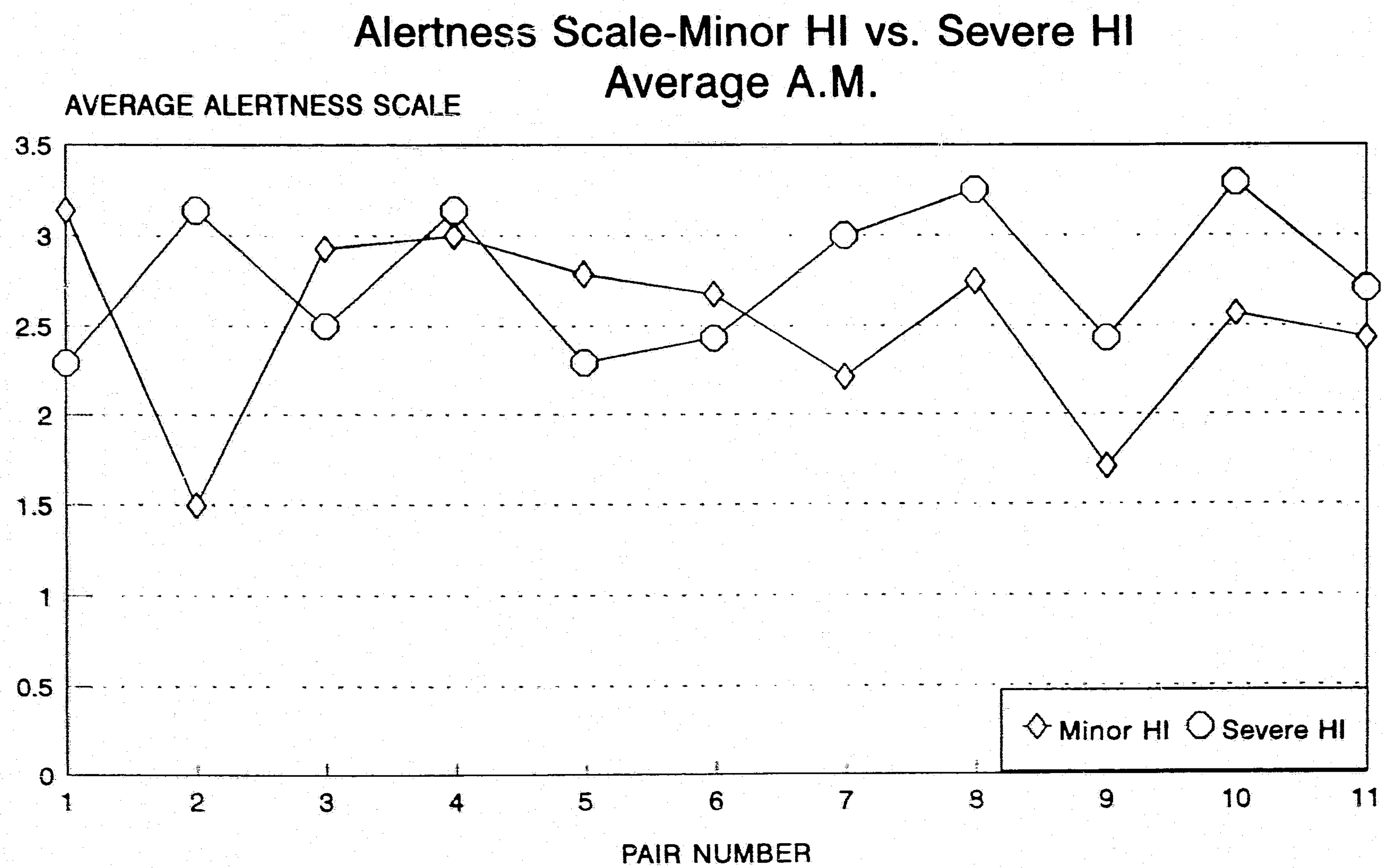


Figure 33. Alertness Scale-Average A.M. for Minor CHI Group vs. Severe CHI Group.

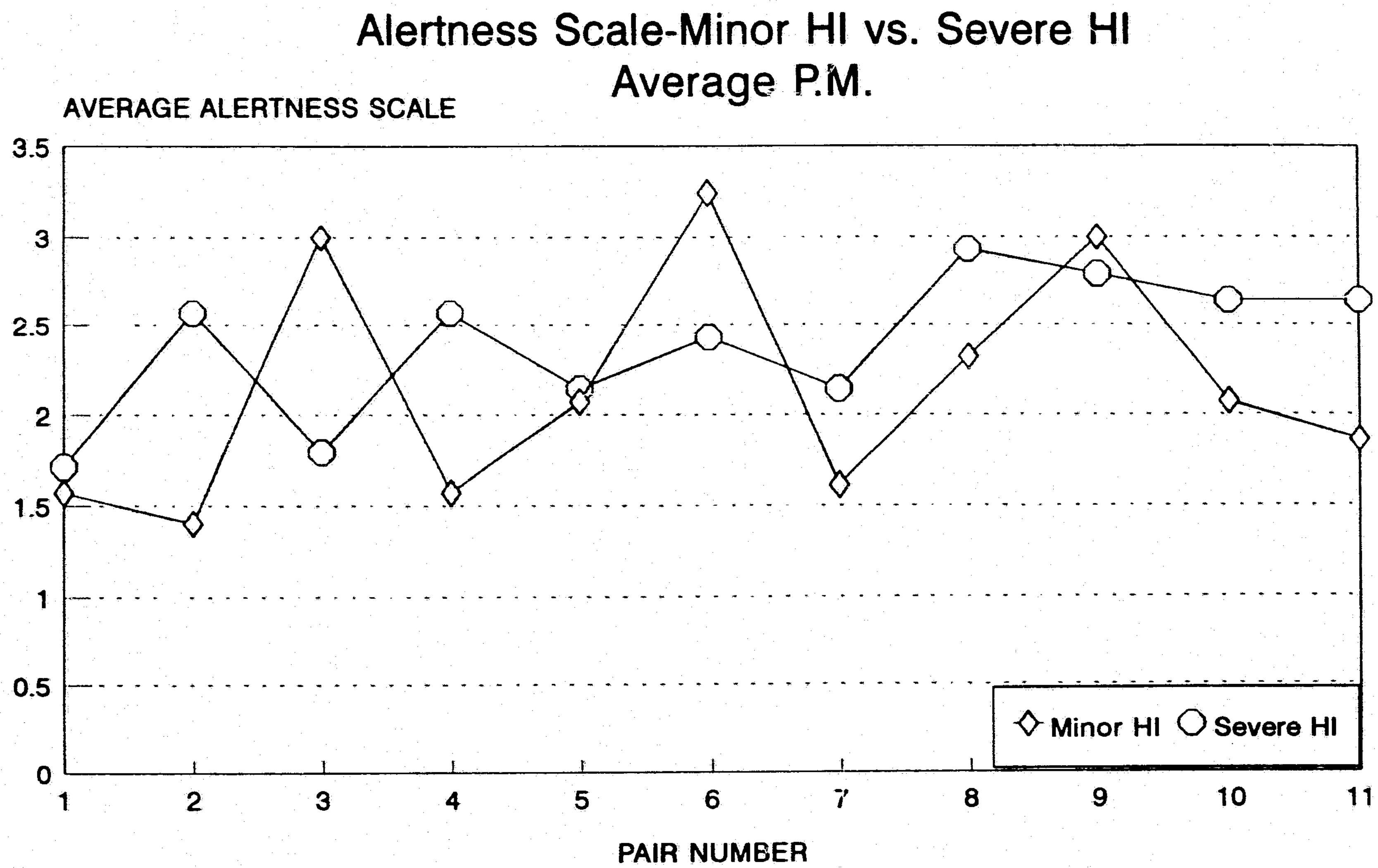


Figure 34. Alertness Scale-Average P.M. for Minor CHI Group vs. Severe CHI Group.

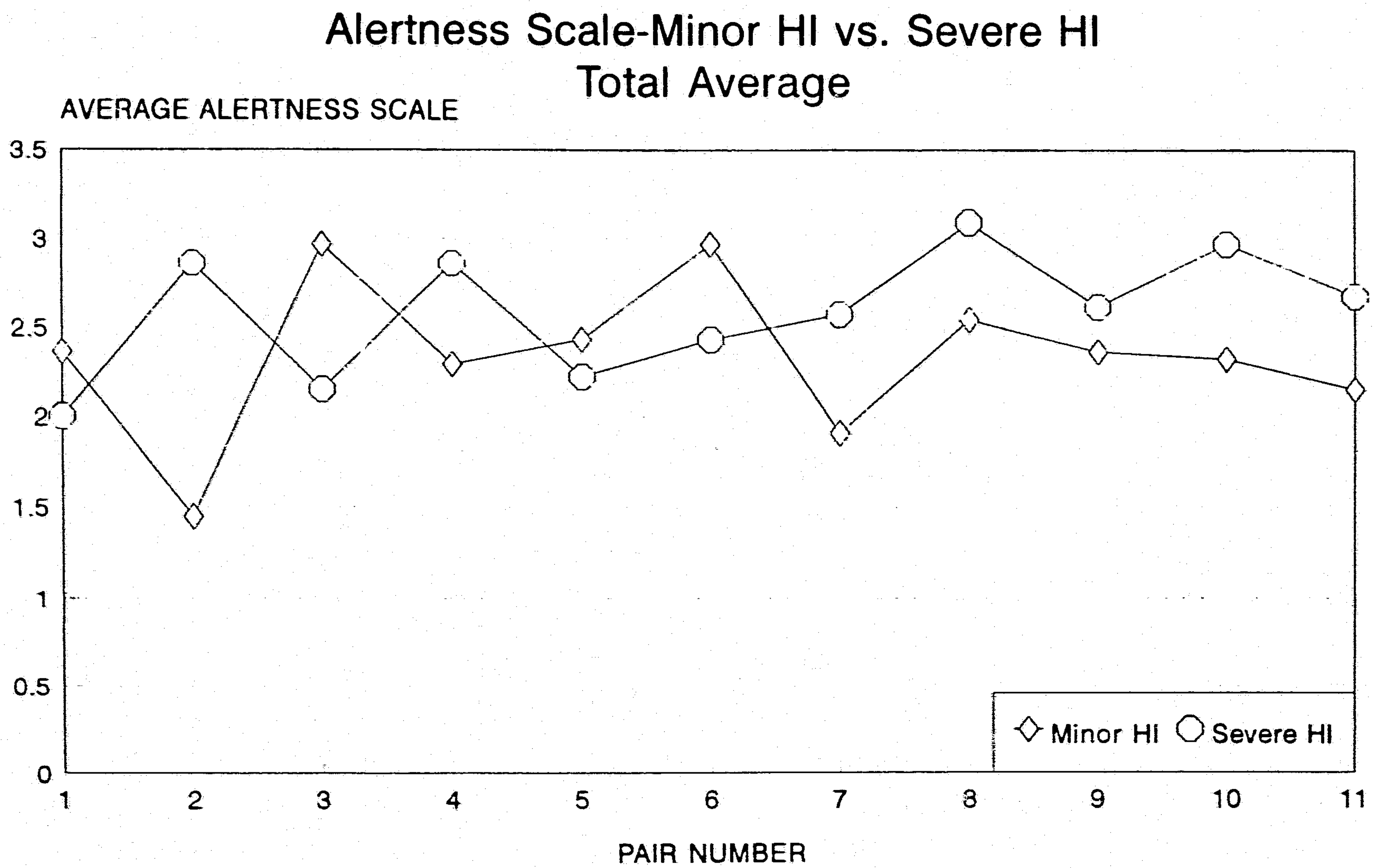


Figure 05. Alertness Scale-Total Average for Minor CHI Group vs. Severe CHI Group.

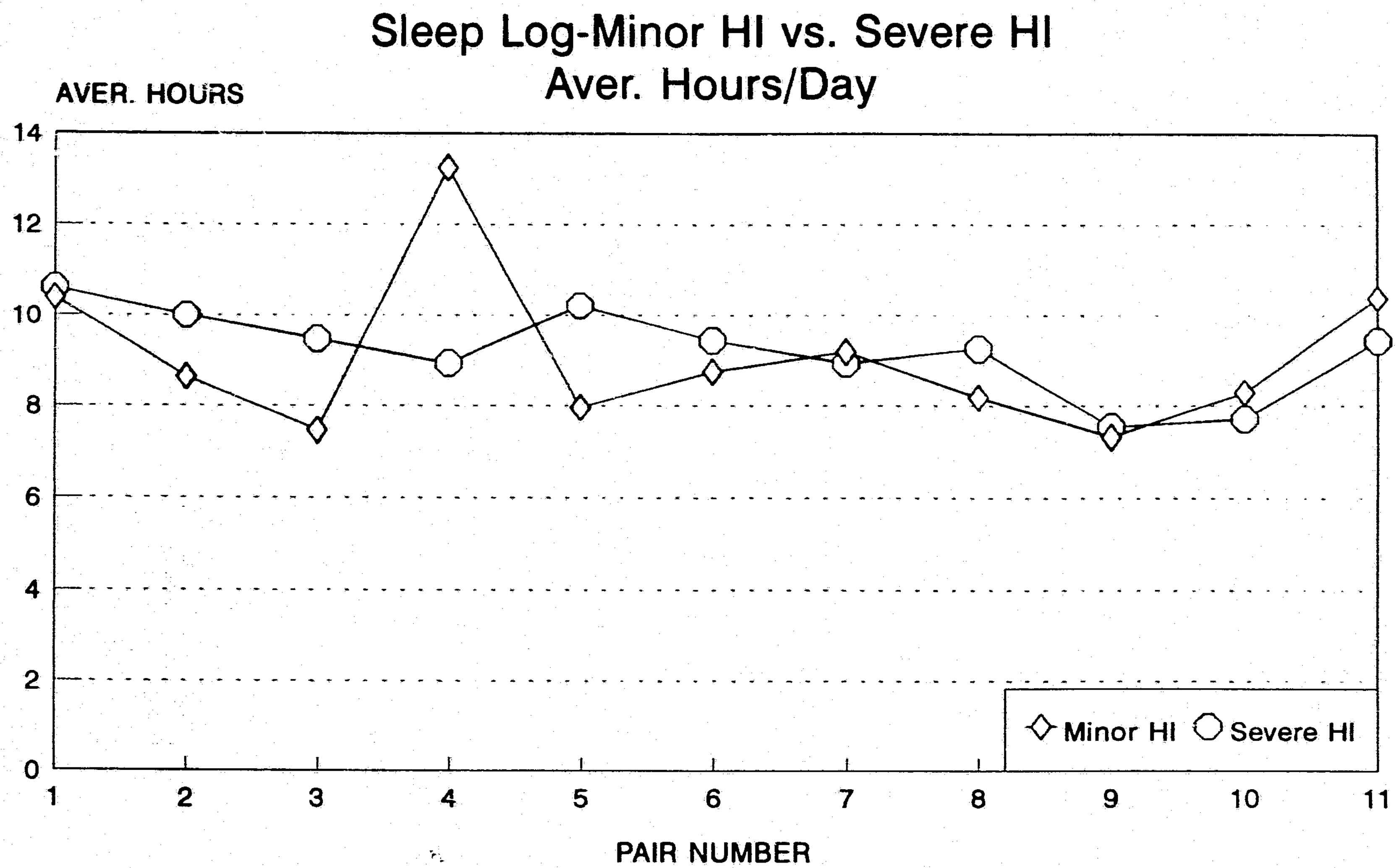


Figure 36. Sleep Log-Average Number of Hours Slept Per Day for Minor CHI Group vs. Severe CHI Group.

Examination of the Relationship Between Length of Post-Traumatic Amnesia and Time Post-Injury and All Other Measures

Tables 7 and 8 contain the results of the correlational analyses examining the relationships between the length of post-traumatic amnesia and all other measures and between the length of time post-injury and all other measures. The correlations with the length of post-traumatic amnesia show a non-significant trend to a lessening of symptoms as the length of post-traumatic amnesia increases. Correlations between the length of time post-injury and the scores on the Depression Scale and the Sleep Log - Average hours per day also show a non-significant trend towards a lessening of symptoms as the time since injury increases. However, correlations with the Vitality Scale, the Vigilance task - total errors, the Sleep Onset task - number of touches and duration, and the Alertness Scale - total average all showed a non-significant trend towards a worsening of symptoms as the length of time post-injury increases.

Table 7

Correlations Between Length of Post-Traumatic Amnesia and All Other Measures

| Variable | Correlation with PTA |
|---|---|
| Depression Scale | -.08 ns |
| Vitality Scale | -.32 ns |
| Vigilance Task | |
| Total Errors | -.00 ns |
| Sleep Onset Task | |
| Touches | -.24 ns |
| Duration | .19 ns |
| Alertness Scale (1) | |
| Total Average | .40 ns |
| Sleep Log (1) | |
| Average/Day (Hours) | -.07 ns |

ns - non-significant

(1) Alertness Scale and Sleep Log analyses have 22 subjects; all other measures have 28 subjects.

NOTE: All of these correlations show a non-significant trend to a lessening of symptoms as length of post-traumatic amnesia increases.

Table 8

Correlations Between Length of Time Post-Injury

And All Other Measures

| Variable | Correlation/Time Post-injury |
| --- | --- |
| Depression Scale | -.31 ns |
| Vitality Scale | .09 ns |
| Vigilance Task | |
| Total Errors | .22 ns |
| Sleep Onset Task | |
| Touches | .11 ns |
| Duration | -.03 ns |
| Alertness Scale (1) | |
| Total Average | -.27 ns |
| Sleep Log (1) | |
| Average/Day (Hours) | -.15 ns |

ns - non-significant
(1) Alertness Scale and Sleep Log analyses used 22 subjects; all other measures used 28 subjects.

NOTE: Correlations for the Depression Scale and the Sleep Log show a non-significant trend to a lessening of symptoms as length of time post-injury increases. All other correlations show a non-significant trend to a worsening of symptoms as length of time post-injury increases.

Relationship Between The Depression Scale and All Other Measures

A 2 X 2 analysis of variance was carried out to explore the possibility of an interaction between the scores on the Depression Scale and those on the other measures. The variables used for the cells in this analysis were Control versus CHI and the scores on the Depression scale. The latter were split at the median to form two groups (those who scored equal to or greater than 9 and those who scored less than 9). The results, shown in Table 9, indicated a significant interaction between the scores on the Depression Scale and the results of the Vitality Scale ($p < .05$), the Sleep Onset task - duration ($p < .005$), the Alertness Scale - total average ($p < .005$), and the Sleep Log - average per day ($p < .05$). There was not a significant interaction between the Depression Scale scores and the Vigilance task - total errors.

Subsequent to the above analysis, an analysis of covariance was carried out with the Depression Scale scores as the covariate. The results, shown in Table 10, indicate that, although the Depression Scale scores contributed significantly to the overall differences, there remained a significant group effect (CHI versus Controls) on all measures when the Depression scores were accounted for.

Table 9

Results of 2 X 2 Anova

(Interaction of Depression with All Other Measures)

| Depression X Variable | F (df = 1,43) |
| --- | --- |
| Vitality Scale | 5.115 ($p < .05$) |
| Vigilance Task - Total Errors | 0.074 ns |
| Sleep Onset Task - Duration | 25.811 ($p < .005$) |
| Alertness Scale - Total Average | 25.899 ($p < .005$) |
| Sleep Log - Average/Day | 5.568 ($p < .05$) |

ns - non-significant

Table 10

Analysis of Variance with Depression as Covariate
(CHI versus Control Groups)

| Variable | F | Significance of F |
|---|---|---|
| Vitality Scale | | |
| Depression | 41.38 | $p < .005$ |
| Group Main Effect | 21.25 | $p < .005$ |
| Vigilance Task - Total Errors | | |
| Depression | 4.10 | $p = .05$ |
| Group Main Effect | 9.22 | $p < .005$ |
| Sleep Onset - Duration | | |
| Depression | 4.21 | $p < .05$ |
| Group Main Effect | 6.30 | $p < .05$ |
| Alertness Scale - Total Average | | |
| Depression | 26.52 | $p < .005$ |
| Group Main Effect | 33.53 | $p < .005$ |
| Sleep Log - Average/Day | | |
| Depression | 5.34 | $p < .05$ |
| Group Main Effect | 8.29 | $p < .05$ |

Summary of Results

The first hypothesis was that the total CHI group and the Control group would be significantly different from each other on all the measures. This was found to be the case. The CHI group scored higher on both the Depression and Vitality Scales (indicating more depressive feelings and less vitality) than did the Control group. The CHI group made more errors than did the Control group on the Vigilance task, although no vigilance decrement was evident. On the Sleep Onset task, the CHI group made more touches in a shorter period of time than did the Control group. Finally, the CHI group reported feeling less alert and sleeping more than did the Control group.

The second hypothesis was that the Minor CHI group would have less evidence of fatigue on all measures than would the Severe CHI group. This hypothesis was not supported. These two groups did not differ on any of the measures. Indeed, the results from the Minor CHI group showed a slight tendency towards more fatigue than did the Severe CHI group. In addition to this lack of group differences, there was also no significant relationship found between length of post-traumatic amnesia and any of the measures.

The third hypothesis was that the CHI subgroups (Minor and Severe) would not be significantly different from each other on the measure of depression. This was the case.

The fourth hypothesis was that there would be a lessening of fatigue indices as the time since injury increased. This was not supported. There was no significant correlation found between the length of time post-injury and any of the measures.

# CHAPTER FOUR

## Discussion

There were several findings in this study that were unpredicted, surprising, or differed from the hypotheses. The various sections of the study will each be discussed, beginning with the demographic results and proceeding through the hypotheses.

### Demographic Results

Based upon the literature, there was no reason to predict that the two CHI subgroups, minor and severe, would be different from each other on their demographic variables. No attempt was made in the study design, therefore, to match these subgroups on their demographics. Although the differences found between these groups make interpretation of some of the results difficult, they also raise some interesting questions. Why would the Minor CHI group be predominantly female rather than male? It is generally believed that there is a greater incidence of head injuries, regardless of severity, in men than in women (Majeres, Demovic & Preston, 1992). The accidents in which the majority of subjects were injured were of the same type in both groups (i.e., motor vehicle accidents) but tended to involve much lower speeds in the Minor CHI group than in the Severe CHI group. It is possible that low speed motor vehicle accidents happen more frequently to women than to men.

A second possibility is that women could be more vulnerable to the effects of a minor closed head injury than are men. Perhaps women are more easily injured or recover less well from this type of injury. No evidence supporting these explanations was found in the literature.

A further possible explanation for the preponderance of women in the Minor CHI group is that women may be more apt to notice or to complain of the effects of a closed head injury. In North America, it may well be more acceptable for a woman to state her concerns to her doctor or to otherwise seek assistance if she is having difficulties than it would be for a man.

In addition to this difference in gender ratio, the Minor and Severe CHI groups differed in both their average age and their average years of education. The Minor CHI group was, on average, ten years older than the Severe CHI group and had two years post-high school education, as compared to less than high school graduation in the Severe CHI group. It may be that, because of their age and education, the Minor CHI group had more responsibilities and greater demands in their lives than did the Severe CHI group. The effects of even a minor closed head injury may be difficult to cope with for those people who are already attempting to manage multiple responsibilities.

A final possibility remains which could explain all of these differences between the Minor CHI and Severe CHI groups. The subjects in the Severe CHI group conformed to the expected pattern, as they were largely young males who were injured in motor vehicle accidents, many of which involved high speeds, alcohol, or both. This group is a specific subgroup of the general population. It may be that those individuals in the Minor CHI group are, in fact, representative of the general population, at least in this particular community.

Any or all of the factors mentioned in this discussion, and others which have not been considered, could be involved in producing the differences observed between the two CHI groups in this study. An investigation of these differences would require a different study and was not the focus of the current research.

Due to the way in which the groups were defined, they would of necessity be significantly different in terms of the length of post-traumatic amnesia. This difference was, therefore, expected. The difference in the amount of time post-injury was not predicted but is understandable. People who sustain a severe closed head injury are generally admitted to the acute care hospital from which they are routinely transferred to the rehabilitation facility as their recovery progresses. In the case of minor injuries, individuals are generally not admitted to hospital and are only referred to the Head Injury Rehabilitation Program if a substantial amount of time has passed and they are still experiencing difficulties. They generally begin the rehabilitation program, therefore, after more time has elapsed since their injury than is the case with more severe injuries. The subjects in this study who had sustained a minor closed head injury were part of the 10 to 25% of all individuals with such an injury who continue to experience difficulties for some time following the injury (Vogenthaler, 1987). This subset of individuals must be different in some way from the 75 - 90% of people who make a full recovery from a minor head injury or who at least do not continue to complain of any difficulties. The nature of this difference is not part of this research but it clearly limits the implications of these results to only this minority of individuals who continue to report difficulties.

Whatever the reasons for the differences in the demographics of the two CHI groups, such differences limit the generalizability of the results of this study to only those populations of individuals who have sustained a closed head injury and who are similar in terms of their demographic variables to the groups investigated here.

CHI Versus Control Group Results

As predicted in the first hypothesis, the CHI and Control groups were significantly different on all measures in the expected direction (i.e., the CHI group reported feeling more depressed and had less of a sense of vitality than the Controls, made more errors on the Vigilance Task, had more key closures and a shorter average duration on the Sleep Onset Task, reported feeling less alert during the day, and slept more than did the Controls). What was not anticipated was the magnitude and clarity of the differences between the groups.

On the measure of depression, of the 28 pairs of subjects, 22 of the CHI subjects reported more feelings of depression than did their matched controls, three pairs reported the same level of depression, and in just three pairs did the Control subjects report more depressive feelings than the CHI subjects. Even though most (20) of the CHI subjects did not score in the clinically depressed range, clearly depression is an important part of the difference between the groups.

The difference was even more evident on the Vitality Scale. In 27 of the 28 pairs, the CHI subjects reported feeling less of a sense of vitality than did their matched controls and, in the case of the single exception to this, the CHI and Control subjects scored equally. Clearly, the individuals in this study who had sustained a closed head injury felt a chronic sense of a loss of vitality or a lowering in their general energy level.

All of the subjects, both CHI and Controls, did surprisingly well on the Vigilance Task, making such a small number of errors that there was in fact no discernible vigilance decrement over time. Perhaps the task was too easy or perhaps it was too short to detect the expected decrement. It was suspected from the outset that the latter might be the case but, because of the somewhat annoying nature of the task, and in the interest of maintaining subject cooperation, it was decided to limit this task to thirty minutes. The number of false positive errors on this task produced the least significant difference of all the group comparisons, although the difference was still significant at the .05 level. Even with the generally small number of errors, both the number of missed targets and the total errors were significantly different between the groups at the .001 level. The CHI subjects tended to be less adept at this task right from the start, which is a similar result to that found in the earlier studies (Brouwer & van Wolffelaar, 1985; Parasuraman, et al, 1991; van Zomeren, et al., 1984). These results are difficult to interpret. It is not clear whether the relatively poor performance of the CHI group was due to a chronic lessening in the CHI subjects' level of cortical arousal or to a specific attentional deficit. It may well be that fatigue (or lowered cortical arousal) and an attentional deficit are dissociable phenomena but this study does not shed any light on this issue.

The difference between the groups on the Sleep Onset measure was again very clear. The CHI subjects had many more instances of key closure (Touches) than did the Control subjects. It must be noted that none of the CHI subjects had any physical problems (weakness or tremor, for example) which could have contributed to this result. The duration measure of this task was even more indicative of the difference between the groups. All but one of the Control subjects managed to last the entire thirty minutes without having fifteen key closures, while only fifteen of the CHI subjects were able to do the same. Two of the CHI subjects actually fell asleep during the task, while several others commented that they had felt very drowsy or had been day-dreaming. In contrast, many of the Control subjects offered the observation that they had used this quiet time to think over plans or problems with which they were currently concerned. None of the Control subjects admitted to having felt sleepy during the task. In the absence of external stimulation the CHI subjects seemed to sink to a lower level of arousal, while the Control subjects seemed to remain actively alert and thinking. This is strong evidence of a deficit in the CHI subjects in the system which maintains normal levels of cortical arousal, perhaps involving either the connections between the reticular formation and the frontal lobes or the frontal lobes themselves. A future study may be able to confirm this observation by pairing the Sleep Onset Task used in this study with physiological measures of arousal.

It is evident from the Alertness Scale results that the CHI group felt slightly less alert than did the Control group in the morning. Of more interest is the fact that the difference between the groups widened as the day progressed. Many of the subjects, both CHI and Control, predicted that they would experience a lowering in their energy level as the day progressed. In actuality, the Control group reported feeling more alert and energetic in mid-afternoon, on average, while the CHI group became less alert. By the afternoon, therefore, every CHI subject, without exception, reported feeling less alert than did their matched control subject. This gradual depletion of energy is further demonstrated by inspection of the sleep logs, which showed that eleven of the twenty-two CHI subjects regularly (at least on three of the seven days covered by the logs) slept in the afternoons, despite sleeping a full seven to ten hours at night. Not a single control subject reported having such naps. A possible factor in this difference is the fact that all of the control subjects were either working or attending school, and so for them it was certainly not convenient to sleep during the day, except on week-ends or non-working days. This was also the case, however, for six of the eleven CHI subjects who regularly napped. These individuals simply slept later in the day (after finishing work or school) than did the other five. In addition, this working- not working factor is potentially confounding as several of the CHI subjects had attempted to return to full-time employment or studies and had been unable to manage it, partly, at least, because of their fatigue.

Further inspection of the sleep logs showed that two of the Minor CHI subjects were still experiencing nightmares which disrupted their sleep on an almost nightly basis. These two individuals had been diagnosed with and received treatment for post-traumatic stress disorder but evidently the treatment had not been entirely successful. This was not known until after the sleep logs had been returned. In retrospect, these subjects probably should not have been included in the study, although excluding their sleep log data does not change the statistical outcome (with these two subjects $\underline{t}$ = 3.71, $p < .005$, without these two subjects $\underline{t}$ =

3.31, $p < .005$).

On average, the CHI subjects slept over one hour more per day than did the Control subjects. Several factors may contribute to this pattern of findings. Perhaps one result of a closed head injury is a brain which works less efficiently than normal, requiring more energy to function and, therefore, exhausting available energy supplies sooner than would an uninjured brain. This could then lead to fatigue and to an increased need for sleep (providing we accept the premise that sleep performs a restorative function, which has yet to be demonstrated). Perhaps the quality of sleep after a closed head injury is somehow changed, leading to the injured individual sleeping longer to obtain the same benefits as an uninjured person. Another possibility is that, as a result of the depression evident in these individuals, the CHI subjects slept more as a way to escape from or to cope with their psychological distress. This study was not designed, however, to investigate the reasons behind the differences but rather to describe the nature and extent of the differences between these particular groups. In order to investigate the possible reasons for this difference, a much more technologically sophisticated study would be required, including the use of a fully equiped sleep lab and various physiological measures, such as EEG's and body temperature.

To further explore the results in relation to the first hypothesis, comparisons were then performed on each of the CHI subgroups and their matched control groups, rather than on the total CHI and control groups.

Minor CHI- Control and Severe CHI- Control Comparisons

The Minor CHI subjects were significantly more depressed than their control subjects ($p < .005$), had less of a sense of vitality ($p < .005$), had more touches on the Sleep Onset Task ($p < .005$), felt less alert in the mornings ($p < .005$), afternoons ($p < .005$), and on average ($p < .005$), and slept more each day ($p < .01$). The number of false positive errors on the Vigilance task was the only non-significant result when comparing the Minor CHI group to the matched control group. A comparison on the Duration measure of the Sleep Onset task could not be computed because of the complete lack of variability on the part of the Control subjects. The two groups were obviously very different, however, as the duration was the maximum (thirty minutes) for all fourteen of the Control subjects while only seven of the fourteen CHI subjects reached this point.

The Severe CHI and Control groups were not as clearly different on most of the measures. In fact, the groups were not significantly different at all on any of the measures from the Vigilance task, on the Duration measure of the Sleep Onset task, or on the average AM measure of the

Alertness Scale. The number of touches on the Sleep Onset task and the average number of hours slept each day were both significantly different for these groups, at the .05 level. The Severe CHI group reported feeling significantly more depressed than their matched controls ($p < .01$), had less of a sense of vitality ($p < .005$), and felt less alert in the afternoons ($p < .005$) and overall ($p < .005$). Some of the other comparisons approached significance (for example, Total Errors on the Vigilance task - $p = .061$) and it is quite possible that a larger group would have yielded significant differences. The fact remains, however, that in this study the large differences between the CHI and Control groups on the Vigilance task and the Sleep Onset task were largely due to the results of the Minor CHI subgroup.

### Minor CHI versus Severe CHI Group Comparisons

The second hypothesis was that there would be a difference between these two groups, with the Minor CHI group showing less evidence of fatigue than the Severe CHI group. It was further postulated that there would be a linear relationship between the measures of fatigue, excluding the depression measure, and the severity of closed head injury, as defined by length of post-traumatic amnesia. This hypothesis was investigated, first, by comparing the results from each of the two subgroups and, second, by performing a correlational analysis on all the data.

When the Minor and Severe CHI subgroups were compared to each other there were no statistically significant differences on any of the measures. Therefore, these two subgroups, despite differences between them in their demographics and the severity of their injuries, were more similar to each other than to the Control subjects. Despite this similarity, when the results on individual measures were examined, it was evident that the Minor CHI group actually scored higher on all indices of fatigue and depression than did the Severe CHI group, except for the Sleep Log in which the Minor CHI group reported sleeping slightly less, on average.

The results of the correlational analysis between the length of post-traumatic amnesia and the measures of fatigue were surprizing in two respects. First, they showed no significant relationships between length of post-traumatic amnesia and any of the measures. Second, the trend was for all the measures to show a decrease in symptom severity as the length of post-traumatic amnesia increased. In other words, subjects with longer periods of amnesia actually reported less depressive feelings and more of a sense of vitality, made fewer errors on the Vigilance task, had fewer touches and lasted for a longer time on the Sleep Onset task, reported feeling more alert, and slept less on average than did those subjects with a shorter period of amnesia.

It is possible that individuals with minor injuries are more aware of and more accurate at reporting their levels of vitality or alertness and are more concerned (and depressed) by their problems. Lack of insight into their situation is a commonly seen problem among individuals with severe closed head injuries (Anderson & Tranel, 1989; Lezak, 1983; McGlynn & Schacter, 1989).

This lack of insight does not explain, however, why the subjects with the relatively minor injuries in this study performed more poorly than did those with more severe injuries on the computerized tasks (the Vigilance and Sleep Onset tasks). It must be remembered that this finding was a non-significant trend. If this trend is replicated in further studies, then several possibilities remain. Either severity of fatigue is not dependent upon the severity of the head injury, or post-traumatic amnesia is not an appropriate measure of severity of closed head injury, or individuals with minor head injuries tend, consciously or not, to exaggerate the extent of their difficulties.

Depression and CHI

The third hypothesis predicted that there would be no significant difference between the CHI subgroups on the measure of depressed mood. This was found to be the case. Because of the clear difference, however, between the CHI subjects and the control subjects on this measure, a further question was considered. This was, what is the relationship between the depression scores and the results on the other measures. This question is especially important since it has been well established that depression by itself can lead to problems with attention and with fatigue or decreased energy.

Two analyses were conducted to explore the relationship between the results on the Depression Scale and the other measures. The first analysis was an analysis of variance and, as expected, it produced a significant interaction between the level of depression and the results on the Vitality Scale, the Sleep Onset Task, the Alertness Scale, and the Sleep Log. The interaction with the Vigilance Task was not significant, providing some evidence that this task was measuring a separate factor. Thus, it is evident that the problems these subjects were experiencing in terms of their energy level were directly related to their psychological status.

To further explore this relationship, a second procedure was completed using the Depression Scale scores as a covariate in the analysis. The results were similar to those found in the first analysis in that there was a significant interaction between the Depression scores and the results on the Vitality Scale, the Sleep Onset Task, the Alertness Scale, and the Sleep Log. However, in every case, including the Vigilance Task, after removing the depression scores from the analysis, there was still a significant group main effect. In other words, the groups were still significantly different on all of the variables. While highly speculative and exploratory, this finding does provide evidence for a difficulty with fatigue in the CHI group beyond that which can be explained on the basis of their level of depression.

Time-Since-Injury and Fatigue

It was predicted in the fourth hypothesis that there would be a decrease in symptom severity as the time since the injury lengthened. This was based on the assumption that fatigue would lessen as the physical healing process proceeded and as the individual learned to adapt to his new circumstances. These two processes may lead to a reduction in depression which would then also contribute to an increase in energy level. The results showed, instead, that there was no significant relationship between time-since-injury and severity of symptoms. There was a trend towards a lessening in reported feelings of depression and a slight decrease in the average number of hours slept each day but all other measures showed a slight trend towards worsening of symptoms as the time since injury increased. This pattern may be an artifact of the previously-noted difference in the two CHI subgroups in that more time had elapsed since the injury in the Minor CHI group than in the Severe CHI group. Thus, time since injury and severity of injury (as measured by length of PTA) are confounded in these groups. A future study should control the time-since-injury factor to avoid this problem.

General Implications of This Study

The operationalized definition of fatigue used in this study was as follows: 1) sleeping for a greater amount of time, as compared to uninjured control subjects; 2) difficulty sustaining alertness over time; and 3) subjective complaints of feeling tired or lacking energy on a chronic basis. Using this definition of fatigue, the CHI group was clearly more fatigued than were their matched control subjects. This was true regardless of the severity of the injury or of the amount of time which had elapsed since the injury. The CHI group also reported more feelings of depression than did the Control group. The depression was evidently a factor in the CHI subjects' level of fatigue but it did not account for all of the difference between the groups. Thus, in the subjects used in this study fatigue appears to be a universal, serious, and long-lasting result of a closed head injury.

In terms of treatment, the implications are as follows. First, individuals who experience a closed head injury should receive treatment for depression. Although medications may be helpful in some cases, for many of the individuals in this study their feelings of depression were not severe enough to warrant being given this form of treatment. Instead, supportive psychotherapy may provide the assistance and support they evidently need to cope with the on-going ramifications of their injury. Second, such individuals should be made aware of the possibility that fatigue will be a source of difficulty in their lives for some time and, therefore, must be taken into account in their plans for returning to work or school. Third, important people in the lives of these individuals (for example, employers, teachers, family members, rehabilitation professionals) should also be made aware of the problem of fatigue so that unrealistic expectations are not placed on the injured persons and so that they are encouraged to rest when they need to. The latter is especially important in the case of those individuals whose injuries have led to a diminished awareness of their internal state. Clinically, it is not unusual to see an individual who denies feeling tired despite clear outward signs of fatigue, such as yawning and eye-closing. Treatment, therefore, should consist of trying to eliminate other possible factors (depression, nightmares, post-traumatic stress disorder, etc.) and then assisting the individual to accomodate to what may be a long-term limitation.

Limitations and Weaknesses of This Study

The current research is very much exploratory in nature. It was designed to investigate the extent of the phenomenon of fatigue after closed head injury. It is not possible to conclude from this research that a closed head injury causes fatigue. It is not even possible to conclude that fatigue is a common symptom of closed head injury. The only conclusion possible is that fatigue was a common experience in this particular group of individuals who had sustained a closed head injury. Before any broader conclusions can be reached, this study should be replicated, hopefully in several different geographical areas and with a larger number of subjects.

A significant weakness of this study was the fact that the researcher knew many (not all) of the CHI subjects and had worked with them as a member of their rehabilitation team. It is possible, then, that the subjects were selected, consciously or not, on the basis of the presence of fatigue. It is further possible that the CHI subjects overstated their difficulties in an attempt to "help" the researcher. These possibilities must be weighed against the difficulty experienced in obtaining any subjects (which would have operated against the researcher accepting only those individuals with a known fatigue problem) and against the results, which showed that every subject, without exception, scored higher then their control on at least some of the fatigue indices (regardless of whether or not they knew the researcher).

A further weakness of this study was the difference between the CHI groups in terms of sex, age, education, and time-since-injury. As discussed earlier, these differences were unpredicted but should have been controlled because of their possibly confounding effects.

From a procedural standpoint, there are several weaknesses in this study. On the Sleep Onset task, there was no way of differentiating key closures which were due to restlessness or impulsivity from those which were due to fatigue. A one-way viewing window would have been useful in determining the degree to which restlessness was a factor. Impulsivity was measured on another of the tasks (the False Positives measure of the Vigilance task) and impulsive key closures were found to occur an average of 3.6 times during the task for the CHI subjects (1.2 times for the Control subjects). Because of the difference in the nature of the tasks, and the explicit instructions given to the subjects to try to avoid key closures during the Sleep Onset task, one cannot simply extrapolate from one task to the other. However, if one did assume that the CHI subjects would make the same number of impulsive key closures on the Sleep Onset task as on the Vigilance task the mean number of key closures would still have been substantially higher for the CHI group than for the Control group.

A second procedural weakness was the reliance on the CHI subjects (who may have both memory and insight problems) to complete several of the measures on their own. The majority of these individuals live on their own or with people who are themselves busy during the day. There was no one available, therefore, in many cases to act as an outside observer or to cue the subjects to complete the measures. There was also some concern about the effect that outside cueing would have on the alertness level of the subjects. In addition, because of the highly subjective nature of alertness, it was not clear that an outside observer could be an accurate judge of this phenomenon. After careful consideration, it was decided to proceed without any external cues or checks on the CHI subjects. While there was no way of determining exactly how the sleep log and alertness scales were completed, the consistency of the results argues against them having been fabricated by the subjects.

Suggestions for Future Research

A number of research questions were raised by this study. Are the demographic differences found in these CHI groups a general trend? Do more women than men sustain minor closed head injuries? Do women recover less well than men from such injuries? Are men less likely to inform their doctors of continuing difficulties than women? Do mature adults (i.e., those people in their thirties) recover less well from closed head injuries than do younger adults (those in their twenties), or do the older individuals simply ask for help more frequently than their younger counterparts? What are the differences between those individuals who recover completely from a minor closed head injury and those who continue to experience difficulties?

Of prime importance to the subject matter of this research is the question of replicability. Would the same results be obtained in other studies using the same measures but larger numbers of subjects? Would the results be the same in a different geographical area, which may have different referral patterns for treatment of closed head injury? Would the results be different if the study was done in a double-blind design? These questions must be answered before we can reach any conclusions regarding the incidence and severity of fatigue as a symptom of closed head injuries of various levels of severity.

Obviously, a basic question in this area is why would fatigue occur following a closed head injury? Technologically sophisticated studies would be required to answer this question. For example, PET scans could be used to examine differences in activity levels of various cerebral areas after a closed head injury. Post-mortem studies may be able to demonstrate very subtle changes to mid-brain regions such as the reticular formation or its connections to the frontal lobes. Sleep studies could be very helpful in determining differences, if any, in the quality of sleep after a closed head injury. This list is not intended to include every possible use of technology to research the question of fatigue after closed head injury but rather contains a small number of suggestions for what could be useful in answering this question.

In terms of treatment, it remains to be seen whether or not therapy for depression would have a significant impact on the indices of fatigue used here. Also, is an attention deficit part and parcel of the larger problem of fatigue or are the two difficulties separate? This question, too, has yet to be clarified.

The two factors of fatigue and depression, which seem to coexist following a head injury, may have far-reaching consequences on the lives of affected individuals. Perhaps one of these was unintentionally exposed in this study with the difficulty encountered in finding CHI subjects who were able to name a close friend who could act as their Control. The very broad area of the psychosocial consequences of a head injury, in which both fatigue and depression may be very important, contains a number of potential areas of research.

Clearly, in this area as in so much of neuropsychology, many more questions remain than answers have been obtained.

Conclusions

This study provides support for the following conclusions:

1) a very high percentage of individuals experience fatigue after a closed head injury;
2) the degree of fatigue which is experienced after a closed head injury is unrelated to the length of post-traumatic amnesia;
3) the degree of fatigue which is experienced after a closed head injury is unrelated to the length of time which has elapsed since the injury;
4) a high percentage of individuals experience depressed mood after a closed head injury;
5) the depressed mood experienced after a closed head injury is a factor in the fatigue but does not entirely account for the fatigue.

Individuals who experience a closed head injury vary widely in the extent to which fatigue is a problem in their lives, but it is the rare individual for whom fatigue is not an issue. In general, fatigue must be considered a potential source of difficulty for every person following a head injury. Fatigue can have an impact on all aspects of an individual's life, from work to education to relationships to leisure activities, and can dramatically change an individual's plans and dreams for the future. Finding an effective treatment for fatigue after a head injury is a very important goal and one which it is hoped will be actively pursued. Such treatment cannot come too soon for those individuals whose lives are affected by fatigue on a daily basis.

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# Appendix A

## Sample Forms Used in this Study

A. Consent Form - Adult Subject

B. Consent Form - Minor Subject

C. Depression Scale

D. Vitality Scale

E. Alertness Scale

F. Sleep Log

## CONSENT FORM

This is to certify that I agree to participate in the "Closed Head Injury" study conducted by Deborah Allison, of the University of Victoria, at the Gorge Road Hospital.

The purpose of the study has been explained to me and I understand the explanation provided.

I have been given an opportunity to ask questions, and all such questions have been answered to my satisfaction.

I understand that I am free to withdraw my consent and terminate my participation in the study at any time. Further, I understand that my participation in this study is entirely unrelated to my treatment at the Gorge Road Hospital.

I understand that all data collected during the study will remain confidential with regard to my identity. All data that are gathered will be filed by a code number.

Date: ______________________

Signature: _________________________

## CONSENT FORM

This is to certify that I consent to my minor child's participation in the "Closed Head Injury" study conducted by Deborah Allison, of the University of Victoria, at the Gorge Road Hospital.

The purpose of the study has been explained to me and I understand the explanation provided.

I have been given an opportunity to ask questions, and all such questions have been answered to my satisfaction.

I understand that I am free to withdraw my consent and terminate my child's participation in the study at any time. Further, I understand that my child's participation in this study is entirely unrelated to his or her treatment at the Gorge Road Hospital.

I understand that all data collected during the study will remain confidential with regard to my child's identity. All data that are gathered will be filed by a code number.

Date: ______________________

Signature of Parent or Guardian: ________________________

## Depression Scale

1) Did you feel depressed (during the past month)?

| | Circle One |
|---|---|
| No - never felt depressed at all | 1 |
| Yes - a little depressed now and then | 2 |
| Yes - quite depressed several times | 3 |
| Yes - very depressed almost every day | 4 |
| Yes - to the point that I did not care about anything | 5 |
| Yes - to the point that I felt like taking my life | 6 |

2) Have you felt so sad, discouraged, hopeless, or had so many problems that you wondered if anything was worthwhile (during the past month)?

| | Circle One |
|---|---|
| Not at all | 1 |
| A little bit | 2 |
| Some - enough to bother me | 3 |
| Quite a bit | 4 |
| Very much so | 5 |
| Extremely so - to the point that I have just about given up | 6 |

Depression Scale (Cont.)

3) Have you felt downhearted and blue (during the past month)?

| | Circle One |
|---|---|
| None of the time | 1 |
| A little of the time | 2 |
| Some of the time | 3 |
| A good bit of the time | 4 |
| Most of the time | 5 |
| All of the time | 6 |

**Vitality Scale**

1) How much energy, pep, or vitality did you have or feel (during the past month)?

| | Circle One |
|---|---|
| Very full of energy - lots of pep | 1 |
| Fairly energetic most of the time | 2 |
| My energy level varied quite a bit | 3 |
| Generally low in energy or pep | 4 |
| Very low in energy or pep most of the time | 5 |
| No energy or pep at all, I felt drained, sapped | 6 |

2) Did you feel active, vigorous <u>or</u> dull, sluggish (during the past month)?

| | Circle One |
|---|---|
| Very active, vigorous every day | 1 |
| Mostly active, vigorous - never really dull, sluggish | 2 |
| Fairly active, vigorous - seldom dull, sluggish | 3 |
| Fairly dull, sluggish - seldom active, vigorous | 4 |
| Mostly dull, sluggish - never really active, vigorous | 5 |
| Very dull, sluggish every day | 6 |

Vitality Scale (Cont.)

3) Have you felt tired, worn out, used up, or exhausted (during the past month)?

| | Circle One |
|---|---|
| None of the time | 1 |
| A little of the time | 2 |
| Some of the time | 3 |
| A good bit of the time | 4 |
| Most of the time | 5 |
| All of the time | 6 |

4) Have you been waking up feeling fresh and rested (during the past month)?

| | Circle One |
|---|---|
| All of the time | 1 |
| Most of the time | 2 |
| A good bit of the time | 3 |
| Some of the time | 4 |
| A little of the time | 5 |
| None of the time | 6 |

## Alertness Scale

Subject Number______

Please indicate your estimation of your alertness by drawing a slash (/) through the line at the place that best describes how alert you feel. Do this twice each day, once between the hours of 9:00 and 10:00 A.M. and again between 3:00 and 4:00 P.M., every day for one week. For example:

Date

May 10/90
Time
9:15

A.M.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Almost Asleep | Drowsy | Normal | Wide Awake | Excited |

Time
3:30

P.M.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Almost Asleep | Drowsy | Normal | Wide Awake | Excited |

Date ______

Time ______ A.M. Drowsy Wide Awake

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Almost Asleep | | Normal | | Excited |

Time ______ P.M. Drowsy Wide Awake

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Almost Asleep | | Normal | | Excited |

Date ______

Time ______ A.M. Drowsy Wide Awake

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Almost Asleep | | Normal | | Excited |

Time ______ P.M. Drowsy Wide Awake

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Almost Asleep | | Normal | | Excited |

Date ______

Time ______ A.M. Drowsy Wide Awake

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Almost Asleep | | Normal | | Excited |

Time ______ P.M. Drowsy Wide Awake

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Almost Asleep | | Normal | | Excited |

Date

______ Time ______

A.M.

| Drowsy | | | Wide Awake | |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| Almost Asleep | | Normal | | Excited |

Time ______

P.M.

| Drowsy | | | Wide Awake | |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| Almost Asleep | | Normal | | Excited |

# Sleep Log

Subject Number______

Please record the hours and time slept each day for one week, from ___________ to _________, 1992, inclusive. For example:

| Date | Time | Total Hours |
|---|---|---|
| May 10 | 1:30 P.M. - 3:00 P.M. | 1.5 |
| | 10:00 P.M. - 7:00 A.M. | 9 |
| | | 10.5 |

| Date | Time | Total Hours |
| --- | --- | --- |

| Date | Time | Total Hours |
| --- | --- | --- |

| Date | Time | Total Hours |
| --- | --- | --- |

| Date | Time | Total Hours |
| --- | --- | --- |

| Date | Time | Total Hours |
|---|---|---|
| ____ | ____ | ____ |
| | ____ | ____ |
| | ____ | ____ |
| | ____ | ____ |
| | | ____ |

| Date | Time | Total Hours |
|---|---|---|
| ____ | ____ | ____ |
| | ____ | ____ |
| | ____ | ____ |
| | ____ | ____ |
| | | ____ |

| Date | Time | Total Hours |
|---|---|---|
| ____ | ____ | ____ |
| | ____ | ____ |
| | ____ | ____ |
| | ____ | ____ |
| | | ____ |

# Appendix B

## Data Lists

A. Demographic Data - Minor CHI and Control Subjects

B. Demographic Data - Severe CHI and Control Subjects

C. Test Data - Minor CHI and Control Subjects

D. Test Data - Severe CHI and Control Subjects

## Demographic Data

## Minor CHI and Control Subjects

| Pair # | Subject # | Sex | Age | Years Educ. | Length of PTA (Hrs.) | Time Since Injury (Mos.) |
|---|---|---|---|---|---|---|
| 1 | CHI 002 | M | 34 | 12 | <1 | 29 |
| | CON 004 | M | 30 | 12 | --- | --- |
| 2 | CHI 007 | F | 32 | 12 | <1 | 33 |
| | CON 016 | F | 34 | 18 | --- | --- |
| 3 | CHI 008 | M | 32 | 12 | <.25 | 19 |
| | CON 013 | M | 27 | 17 | --- | --- |
| 4 | CHI 010 | M | 32 | 16 | <.08 | 11 |
| | CON 017 | M | 32 | 12 | --- | --- |
| 5 | CHI 018 | F | 35 | 17 | <.25 | 18 |
| | CON 023 | F | 35 | 15 | --- | --- |
| 6 | CHI 019 | F | 34 | 20 | <.25 | 38 |
| | CON 020 | F | 36 | 17 | --- | --- |
| 7 | CHI 024 | F | 33 | 16 | <.25 | 18 |
| | CON 026 | F | 28 | 16 | --- | --- |
| 8 | CHI 025 | F | 29 | 13 | <.25 | 39 |
| | CON 032 | F | 27 | 17 | --- | --- |
| 9 | CHI 028 | F | 38 | 14 | <.25 | 61 |
| | CON 029 | F | 43 | 14 | --- | --- |
| 10 | CHI 030 | F | 30 | 17 | <.25 | 08 |
| | CON 031 | F | 26 | 14 | --- | --- |
| 11 | CHI 037 | F | 35 | 12 | <.25 | 13 |
| | CON 042 | F | 35 | 13 | --- | --- |
| 26 | CHI 052 | M | 41 | 12 | <.08 | 21 |
| | CON 053 | M | 38 | 16 | --- | --- |
| 27 | CHI 021 | M | 37 | 12 | <.25 | 24 |
| | CON 054 | M | 40 | 12 | --- | --- |
| 28 | CHI 027 | F | 41 | 15 | <.25 | 59 |
| | CON 055 | F | 37 | 16 | --- | --- |

Demographic Data

Severe CHI and Control Subjects

| Pair # | Subject # | Sex | Age | Years Educ. | Length of PTA (Hrs.) | Time Since Injury (Mos.) |
|---|---|---|---|---|---|---|
| 12 | CHI 001 | M | 32 | 12 | 168 | 22 |
| | CON 009 | M | 31 | 20 | --- | --- |
| 13 | CHI 003 | M | 20 | 13 | >1344 | 11 |
| | CON 014 | M | 20 | 13 | --- | --- |
| 14 | CHI 012 | F | 18 | 12 | 336 | 14 |
| | CON 015 | F | 22 | 12 | --- | --- |
| 15 | CHI 022 | M | 29 | 18 | 3360 | 18 |
| | CON 011 | M | 26 | 15 | --- | --- |
| 16 | CHI 033 | F | 25 | 10 | 48 | 46 |
| | CON 034 | F | 27 | 15 | --- | --- |
| 17 | CHI 035 | M | 21 | 10 | 48 | 16 |
| | CON 038 | M | 23 | 12 | --- | --- |
| 18 | CHI 036 | M | 22 | 12 | 48 | 19 |
| | CON 039 | M | 20 | 13 | --- | --- |
| 19 | CHI 040 | F | 21 | 10 | 336 | 05 |
| | CON 043 | F | 21 | 12 | --- | --- |
| 20 | CHI 041 | F | 16 | 11 | 168 | 04 |
| | CON 044 | F | 17 | 11 | --- | --- |
| 21 | CHI 048 | M | 37 | 12 | 1440 | 04 |
| | CON 050 | M | 42 | 12 | --- | --- |
| 22 | CHI 049 | M | 34 | 12 | 168 | 10 |
| | CON 051 | M | 29 | 14 | --- | --- |
| 23 | CHI 045 | M | 31 | 11 | 72 | 15 |
| | CON 046 | M | 28 | 10 | --- | --- |
| 24 | CHI 047 | F | 19 | 10 | 336 | 31 |
| | CON 056 | F | 22 | 12 | --- | --- |
| 25 | CHI 057 | F | 21 | 10 | 336 | 07 |
| | CON 058 | F | 21 | 12 | --- | --- |

## Test Data

### Minor CHI and Control Subjects

| Pair # | Subject # | Depression Score | Vitality Score | Vigilance Task False +'s | Misses | Total |
|---|---|---|---|---|---|---|
| 1 | CHI 002 | 12 | 13 | 0 | 3 | 3 |
| | CON 004 | 4 | 7 | 0 | 0 | 0 |
| 2 | CHI 007 | 10 | 20 | 15 | 4 | 19 |
| | CON 016 | 7 | 10 | 2 | 0 | 2 |
| 3 | CHI 008 | 9 | 11 | 3 | 0 | 3 |
| | CON 013 | 5 | 9 | 0 | 0 | 0 |
| 4 | CHI 010 | 5 | 17 | 2 | 2 | 4 |
| | CON 017 | 3 | 8 | 2 | 0 | 2 |
| 5 | CHI 018 | 6 | 15 | 0 | 2 | 2 |
| | CON 023 | 6 | 10 | 1 | 0 | 1 |
| 6 | CHI 019 | 7 | 18 | 6 | 0 | 6 |
| | CON 020 | 4 | 10 | 0 | 0 | 0 |
| 7 | CHI 024 | 15 | 21 | 3 | 4 | 7 |
| | CON 026 | 5 | 14 | 2 | 0 | 2 |
| 8 | CHI 025 | 6 | 16 | 10 | 3 | 13 |
| | CON 032 | 6 | 9 | 0 | 0 | 0 |
| 9 | CHI 028 | 7 | 17 | 14 | 4 | 18 |
| | CON 029 | 5 | 12 | 9 | 0 | 9 |
| 10 | CHI 030 | 11 | 18 | 0 | 0 | 0 |
| | CON 031 | 3 | 6 | 0 | 0 | 0 |
| 11 | CHI 037 | 11 | 17 | 2 | 10 | 12 |
| | CON 042 | 7 | 10 | 0 | 0 | 0 |
| 26 | CHI 052 | 7 | 14 | 0 | 1 | 1 |
| | CON 053 | 6 | 11 | 0 | 0 | 0 |
| 27 | CHI 021 | 13 | 20 | 3 | 1 | 4 |
| | CON 054 | 5 | 9 | 0 | 1 | 1 |
| 28 | CHI 027 | 6 | 14 | 0 | 1 | 1 |
| | CON 055 | 6 | 9 | 0 | 0 | 0 |

## Test Data

### Minor CHI and Control Subjects (Cont.)

| Pair # | Subject # | Sleep Onset No. of Touches | Sleep Onset Dura. (Min) | Alertness Scale Ave. AM | Alertness Scale Ave. PM | Alertness Scale Total Ave. | Sleep Log Ave.Hours/ Day |
|---|---|---|---|---|---|---|---|
| 1 | CHI 002 | 15 | 20.7 | 3.14 | 1.57 | 2.36 | 10.39 |
| | CON 004 | 4 | 30.0 | 3.29 | 4.00 | 3.65 | 7.73 |
| 2 | CHI 007 | 15 | 12.[illegible] | 1.50 | 1.40 | 1.45 | 8.64 |
| | CON 016 | 0 | 30.0 | 3.14 | 4.00 | 3.57 | 8.04 |
| 3 | CHI 008 | 2 | 30.0 | 2.93 | 3.00 | 2.97 | 7.46 |
| | CON 013 | 0 | 30.0 | 3.57 | 4.14 | 3.86 | 9.00 |
| 4 | CHI 010 | 15 | 8.3 | 3.00 | 1.57 | 2.29 | 13.25 |
| | CON 017 | 0 | 30.0 | 3.07 | 3.00 | 3.04 | 7.36 |
| 5 | CHI 018 | 15 | 25.2 | 2.79 | 2.07 | 2.43 | 7.96 |
| | CON 023 | 0 | 30.0 | 3.43 | 3.00 | 3.22 | 7.29 |
| 6 | CHI 019 | 15 | 19.0 | 2.68 | 3.25 | 2.97 | 8.75 |
| | CON 02[illegible] | 0 | 30.0 | 3.21 | 3.43 | 3.32 | 7.21 |
| 7 | CHI 024 | 0 | 30.0 | 2.21 | 1.61 | 1.91 | 9.18 |
| | CON 026 | 1 | 30.0 | 3.79 | 3.36 | 3.58 | 7.82 |
| 8 | CHI 025 | 9 | 30.0 | 2.75 | 2.32 | 2.54 | 8.18 |
| | CON 032 | 0 | 30.0 | 2.86 | 3.14 | 3.00 | 7.96 |
| 9 | CHI 028 | 1 | 30.0 | 1.71 | 3.00 | 2.36 | 7.32 |
| | CON 029 | 0 | 30.0 | 4.07 | 3.07 | 3.57 | 5.43 |
| 10 | CHI 030 | 0 | 30.0 | 2.57 | 2.07 | 2.32 | 8.29 |
| | CON 031 | 0 | 30.0 | 3.71 | 2.71 | 3.21 | 8.00 |
| 11 | CHI 037 | 15 | 10.4 | 2.43 | 1.86 | 2.15 | 10.39 |
| | CON 042 | 0 | 30.0 | 2.57 | 3.57 | 3.07 | 7.61 |
| 26 | CHI 052 | 2 | 30.0 | N\A | N\A | N\A | N\A |
| | CON 053 | 0 | 30.0 | N\A | N\A | N\A | N\A |
| 27 | CHI 021 | 8 | 30.0 | N\A | N\A | N\A | N\A |
| | CON 054 | 1 | 30.0 | N\A | N\A | N\A | N\A |
| 28 | CHI 027 | 15 | 19.2 | N\A | N\A | N\A | N\A |
| | CON 055 | 0 | 30.0 | N\A | N\A | N\A | N\A |

Test Data

Severe CHI and Control Subjects

| Pair # | Subject # | Depression Score | Vitality Score | Vigilance Task False +'s | Misses | Total |
|---|---|---|---|---|---|---|
| 12 | CHI 001 | 6 | 13 | 4 | 4 | 8 |
| | CON 009 | 7 | 13 | 0 | 0 | 0 |
| 13 | CHI 003 | 6 | 12 | 5 | 2 | 7 |
| | CON 014 | 4 | 11 | 6 | 1 | 7 |
| 14 | CHI 012 | 15 | 19 | 1 | 2 | 3 |
| | CON 015 | 8 | 15 | 1 | 1 | 2 |
| 15 | CHI 022 | 8 | 14 | 0 | 2 | 2 |
| | CON 011 | 6 | 8 | 0 | 0 | 0 |
| 16 | CHI 033 | 6 | 17 | 0 | 2 | 2 |
| | CON 034 | 7 | 14 | 0 | 0 | 0 |
| 17 | CHI 035 | 7 | 16 | 4 | 0 | 4 |
| | CON 038 | 3 | 8 | 1 | 0 | 1 |
| 18 | CHI 036 | 9 | 18 | 1 | 3 | 4 |
| | CON 039 | 6 | 12 | 3 | 0 | 3 |
| 19 | CHI 040 | 7 | 17 | 4 | 1 | 5 |
| | CON 043 | 4 | 12 | 3 | 2 | 5 |
| 20 | CHI 041 | 12 | 16 | 6 | 0 | 6 |
| | CON 044 | 14 | 13 | 1 | 3 | 4 |
| 21 | CHI 048 | 10 | 12 | 15 | 0 | 15 |
| | CON 050 | 3 | 9 | 0 | 0 | 0 |
| 22 | CHI 049 | 9 | 11 | 0 | 0 | 0 |
| | CON 051 | 3 | 9 | 0 | 0 | 0 |
| 23 | CHI 045 | 14 | 20 | 0 | 0 | 0 |
| | CON 046 | 4 | 9 | 0 | 0 | 0 |
| 24 | CHI 047 | 7 | 17 | 0 | 0 | 0 |
| | CON 056 | 3 | 11 | 0 | 0 | 0 |
| 25 | CHI 057 | 7 | 17 | 4 | 1 | 5 |
| | CON 058 | 4 | 10 | 3 | 2 | 5 |

## Test Data

### Severe CHI and Control Subjects (Cont.)

| Pair # | Subject # | Sleep Onset # Of Touches | Sleep Onset Dura. (Min.) | Alertness Scale Ave. AM | Alertness Scale Ave. PM | Alertness Scale Total Ave. | Sleep Log Ave.Hours/ Day |
|---|---|---|---|---|---|---|---|
| 12 | CHI 001 | 15 | 12.7 | 2.29 | 1.71 | 2.00 | 10.61 |
| | CON 009 | 0 | 30.0 | 3.86 | 2.64 | 3.25 | 7.64 |
| 13 | CHI 003 | 15 | 24.5 | 3.14 | 2.57 | 2.86 | 10.00 |
| | CON 014 | 4 | 30.0 | 2.29 | 3.57 | 2.93 | 8.29 |
| 14 | CHI 012 | 15 | 10.0 | 2.50 | 1.79 | 2.15 | 9.46 |
| | CON 015 | 5 | 30.0 | 2.43 | 2.71 | 2.57 | 8.00 |
| 15 | CHI 022 | 0 | 30.0 | 3.14 | 2.57 | 2.86 | 8.93 |
| | CON 011 | 7 | 30.0 | 3.43 | 3.71 | 3.57 | 8.07 |
| 16 | CHI 033 | 4 | 30.0 | 2.29 | 2.14 | 2.22 | 10.21 |
| | CON 034 | 1 | 30.0 | 2.79 | 3.79 | 3.29 | 7.82 |
| 17 | CHI 035 | 15 | 28.8 | 2.43 | 2.43 | 2.43 | 9.43 |
| | CON 038 | 3 | 30.0 | 3.00 | 3.60 | 3.30 | 7.89 |
| 18 | CHI 036 | 15 | 05.3 | 3.00 | 2.14 | 2.57 | 8.93 |
| | CON 039 | 15 | 18.6 | 2.14 | 4.00 | 3.07 | 8.07 |
| 19 | CHI 040 | 2 | 30.0 | 3.25 | 2.93 | 3.09 | 9.25 |
| | CON 043 | 8 | 30.0 | 3.00 | 3.29 | 3.14 | 7.43 |
| 20 | CHI 041 | 8 | 30.0 | 2.43 | 2.79 | 2.61 | 7.54 |
| | CON 044 | 4 | 30.0 | 2.93 | 3.93 | 3.43 | 10.54 |
| 21 | CHI 048 | 5 | 30.0 | 3.29 | 2.64 | 2.97 | 7.71 |
| | CON 050 | 0 | 30.0 | 3.50 | 3.71 | 3.60 | 7.82 |
| 22 | CHI 049 | 0 | 30.0 | 2.71 | 2.64 | 2.67 | 9.43 |
| | CON 051 | 0 | 30.0 | 3.07 | 2.85 | 2.96 | 8.21 |
| 23 | CHI 045 | 15 | 29.1 | N\A | N\A | N\A | N\A |
| | CON 046 | 1 | 30.0 | N\A | N\A | N\A | N\A |
| 24 | CHI 047 | 10 | 30.0 | N\A | N\A | N\A | N\A |
| | CON 056 | 3 | 30.0 | N\A | N\A | N\A | N\A |
| 25 | CHI 057 | 2 | 30.0 | N\A | N\A | N\A | N\A |
| | CON 058 | 8 | 30.0 | N\A | N\A | N\A | N\A |