

Planning disorders in men with schizophrenia and in men with localized frontal lobe lesions

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Summary

Aim. Planning disorders have been observed in people with frontal lobe lesions for many decades. There's also growing body of evidence of frontal dysfunction in people with schizophrenia. The aim of this study is to compare the planning abilities in men with schizophrenia, men with localized frontal lobe lesions and healthy men.

Method. A sample of 90 men participated in the study. They were divided into three groups: men with schizophrenia (n=30), men with localized frontal lobe lesions (n=30) and healthy men (n=30) as a control group. Planning abilities were assessed with a clinical trial based on Tower of London task.

Results. Significant differences in ToL measures were found between controls and men with schizophrenia (Trials solved: $p < 0.01$; Trials solved perfectly: $p < 0.05$; Execution time: $p < 0.001$) and between controls and men with frontal lobe lesions (Trials solved: $p < 0.001$; Thinking time: $p < 0.05$; Execution time: $p < 0.001$). No significant differences were found between schizophrenia and frontal lobe lesion groups.

Conclusions. Similar deficits in planning and solving problems, which require planning, may be observed in men with schizophrenia and men with frontal lobe lesions. In both groups time spent on thinking is less effective than in healthy men. Not only quantitative, but also qualitative assessment should be carried when examining patients' performance on Tower of London task.

Key words: schizophrenia, frontal lobe, planning

Introduction

The concept of existence of the executive system, which is superior to the cognitive one and vital for all the aspects of human functioning, is one of the most basic ideas in brain-behavior research nowadays [1]. There is a wide agreement among researchers that executive system is linked to the frontal lobes. [1-3]. Both lesion [4] and neuroimaging [5] studies brought evidence that this view is correct.

Planning ability, which enables man to function in a purposeful and reflective manner, is a crucial part of executive system. Porteus [6] has already pointed up the central role of frontal lobes in planning and problem solving. The opinion that planning

may be connected with the activity of the dorsolateral prefrontal cortex was confirmed both by studies conducted on frontal lobe lesions patients [7] and neuroimaging studies of healthy participants [8]. Shallice [9] while presenting Tower of London task, which is contemporary the most common “tower task”, proposed it as the frontal lobe activity assessment tool. “Tower tasks” are, as Walsh and Darby [10] state, “far more characterized by planning factor than any other neuropsychological test”. Review of the research of clinical applications of various clinical trials based on Tower of London task reveals that, no matter of the difficulty of the trial used, patients with frontal lobe lesions displayed worse task performance than healthy controls [7, 11, 12]. Deficits in planning observed in patients with frontal lobe lesions are considered to be irrespective of working memory disorders [11], but related to the disability of conforming to the imposed rules while solving a problem [13], impulsiveness which leads to starting activity without elaborated strategy of action [7] and inability to act while facing goal-subgoal conflict [14].

Executive function deficits [15, 16], including planning disorders, are one of the most frequently observed neuropsychological deficits in schizophrenia. Their importance is being emphasized, especially in the context of neurodevelopmental theory of schizophrenia [17] and abnormalities in prefrontal cortex structure and function observed among patients [18]. Specific deficits in planning are confirmed by the results of the studies, which indicate that patients with schizophrenia are impaired in “tower tasks” when compared to the healthy controls [16,19]. Some of the researchers claim that planning deficits are one of the most specific neuropsychological deficits in schizophrenia [20], while others suggest that they are related to the working memory deficits [21].

Despite that planning deficits, both in schizophrenia and frontal lobe lesion patients, have been drawing a lot of attention of the researchers, only handful of studies comparing both groups are available [22, 23]. In this paper direct comparison of the planning ability among schizophrenia patients, frontal lobe lesion patients and healthy controls is outlined.

Material

A sample of 90 men, divided into three even groups, participated in the study. First group was combined of men with frontal lobe lesions (“O” group), who were recruited from patients of Department of Neurosurgery and Oncology of the Central Nervous System, Medical University of Lodz (fourteen participants), Neurosurgical Ward, Wyszyński Hospital in Sieradz (eleven participants) and Neurosurgical Ward, Skłodowska-Curie Provincial Hospital in Zgierz (five participants). Patients were qualified for the study on the basis of the following criteria: sex (male), age (between 28 and 58 years old) and diagnosis based on CT/MRI examination (lesions of dorsolateral parts of frontal lobes). Following criteria of exclusion of the patient from the study were applied: diagnosis of lesions which were not restricted to the frontal lobes (i.e. localized lesions which extended from frontal lobes to other cortical or subcortical structures, lesions of other brains structures (e.g. *contre-coup* lesions) or coexisting

diffused brain injuries), diagnosis of comorbid psychiatric disorders. Data of patients observed with aphasia or disorders of alertness or consciousness during the examination were excluded from further analyses. In the group of thirty lesions amid twenty-one were caused by traumatic brain injuries, eight patients suffered from tumors and one from vascular disease. Sixteen patients had unilateral frontal lobe lesions (8 right and 8 left) and fourteen had bilateral lesions. Second group ("P") consisted of thirty men with schizophrenia, who were recruited from patients of Units VIIIb (five participants) and IXb (eleven participants) of Babiński Hospital in Łódź and Male Psychiatric Ward, Skłodowska-Curie Provincial Hospital in Zgierz (fourteen participants). Diagnosis of schizophrenia, based on ICD-10 criteria, as well as sex (male) and age (between 28 and 58 years old) were the basis of including the patient into the study. Patients who were diagnosed with the psychoactive substance dependence or other comorbid psychiatric disorders or had any medical history of neurological disorders or traumatic brain injuries were excluded from the study. Data collected from patients who presented marked positive or negative symptoms which may affected the variables observed in the study were excluded from further analyses.

Control group ("K") consisted of healthy men with no record of traumatic brain injuries or neurological or psychiatric treatment. Volunteers who were matched to the patients with respect to age and education were recruited to control group.

Participants' mean age in the group O was 43.33 years old (SD = 9.99 year), in the group P 45.67 years old (SD = 7.52 year) and in the group K 42.97 years old (SD = 9.32). In the group O 22 patients held basic or vocational academic level, six completed secondary education and two completed tertiary education. Of the patients from P group eighteen held basic or vocational academic level, ten completed secondary education and two completed tertiary education. Control group (K) consisted of fifteen men with basic or vocational educational level, twelve with secondary academic level and three with tertiary academic level. No significant differences in age or educational level were found between the groups. Each participant was fully informed about the procedure and gave voluntary consent before participating in the study.

Method

Tower of London task (ToL) is considered to be a tool, which allows to assess deficits in planning more accurately than other methods available [1]. It was created by Shallice [9] for the purpose of assessing functioning of the "supervisory attentional system" in frontal lobe lesion patients. Culbertson and Zilmer [24] developed norms for ToL evaluation for American patients. Also computerized versions of ToL are available, it is included i.a. in CANTAB battery [25]. Because no Polish standardization of the task is available, clinical trial based on procedures described by Shallice [9] and Culbertson and Zilmer [24] was used in this study.

Proper fulfillment of the ToL task requires an ability to plan and implement a strategy aimed to solve a problem [1]. Ability to distinguish subgoals, which are essential for accomplishing the final goal, is also necessary in the case of more difficult examples [10].

ToL procedure is based on the use of board with three pegs on which three coloured (red, green, blue) balls can be placed. Longest peg can hold up to three balls; up to the two balls can be put on the middle peg and only one ball can be placed on the shortest peg. Participant is told to arrange, by doing as little moves as possible, balls on his peg in the same manner as they are arranged on the researchers board. Two rules should be obeyed while performing the task: participant is not allowed to move more than one ball at the same time, neither should he place more balls on the peg, than it can contain. After two training problems participant is presented with ten test problems. Difficulty of the task increases from the four to the seven moves essential to complete the problem. Time limit for each problem is two minutes.

Tower of London procedure was a part of larger neuropsychological assessment battery, which was aimed to examine the executive functioning of participants. ToL task was conducted at the beginning of the examination and lasted for 15-25 minutes.

Descriptive statistics of the quantitative indicators of task performance were applied for the purpose of the results analysis. Because the aim of the study is to compare the paired results of the task performance in three groups, one-way ANOVA analysis and post-hoc tests were used.

Results

Four different measures of ToL performance were analyzed: number of problems solved, number of problems solved perfectly (without additional moves), total time of planning (measured until the first move), total time of execution. Basic descriptive statistics of these measures in each group are shown in Tab. 1.

Table 1. **Descriptive statistics of Tower of London task scores in men with frontal lobe lesions (O), men with schizophrenia (P) and healthy controls (K)**

Tower of London task score	Group O		Group P		Group K	
	M	SD	M	SD	M	SD
Problems solved	7.43	2.90	8.90	1.52	9.93	0.25
Problems solved perfectly	3.4	2.06	3.3	1.51	4.8	2.58
Planning time	137.93	86.58	106.20	57.81	91.20	64.41
Execution time	533.27	249.42	444.70	207.95	239.53	81.21

During the first step of the statistical analysis of the results one-way ANOVA analysis was performed. Due to the lack of the homogeneity of the variance in groups for all of the variables with the exception of Planning time (Levene's test $p=0.07$) Welch's and Brown-Forsythe's tests were additionally performed. Results of the analysis are summed up in the Tab. 2 – *next page*.

Results of the first step of the analysis indicate that groups differ significantly in all of the analyzed measures. In the second step of the analysis post hoc test were performed: T2 Tamhane's test for all of the variables with nonhomogeneous variance and Scheffe's test for Planning time.

Table 2. **One-way ANOVA and Welch's and Brown-Forsythe's tests of the Tower of London task scores in men with frontal lobe lesions (O), men with schizophrenia (P) and healthy controls (K)**

Tower of London task score	ANOVA		Welch's	Brown – Forsythe's
	F	p	P	P
Problems solved	13.205	0.000***	0.000***	0.000***
Problems solved perfectly	4.827	0.01*	0.025*	0.011*
Planning time	3.419	0.037*	-	-
Execution time	18.235	0.000***	0.000***	0.000***

* p<0.05 ** p<0.01 *** p<0.001

Table 3. **Post-hoc analysis of the Tower of London task scores in in men with frontal lobe lesions (O), men with schizophrenia (P) and healthy controls (K)**

Tower of London task score	O vs K	P vs K	O vs P
	p	p	p
Problems solved	0.000***	0.003**	0.053
Problems solved perfectly	0.069	0.024*	0.995
Planning time	0.042*	0.714	0.226
Execution time	0.000***	0.000***	0.366

* p<0.05 ** p<0.01 *** p<0.001

Post hoc analysis revealed significant differences between clinical groups and control group in almost all quantitative measures of ToL performance, except Problems solved perfectly (no differences between O and K groups) and Planning time (no differences between P and K groups). No significant differences were found between both clinical groups, although test result for the Number of problems solved was on the edge of the statistical significance (p=0.053).

Discussion

In both clinical groups weaker ability to solve problems which require planning was observed than in a control group. In men with schizophrenia effectiveness of planning (measured by number of problems solved without additional moves) was also lower than in healthy participants.

Post hoc analysis revealed that both clinical groups are comparable in respect to the ability to solve problems which require planning, although the test result was on the edge of significance ($\alpha=0.053$). In both clinical groups the samples of patients who solved all of the presented problems were corresponding in number. However only in the frontal lobe lesion group number of patients, who were not able to solve more than half of the presented problems, was noticeable. Effectiveness of planning, measured by number of problems solved without additional moves, did not differentiate one clinical group from the other.

Despite the fact, that statistical analysis leads to conclusion that there are no significant differences between clinical groups, nature of the deficits in both groups was not identical. Majority of the men with schizophrenia showed similar intensity and characteristics of deficits. They were able to solve the bulk of the problems (albeit still less than healthy participants), however solutions which have been produced by them were chaotic and ineffective and often included redundant, pointless activities.

Men with localized frontal lobe lesions varied widely in terms of the planning deficits. On the one hand patients with lesions presented more frequently intact planning ability than patients with schizophrenia, but on the other in some of the patients from this group the most severe deficits were found. Problems with planning, which hindered these patients in their efforts to create effective (or, in many cases, any) plan of solving the problem, were related mostly to the inability to postpone the actions directed to reach immediately the final goal.

Style of action neither in men with schizophrenia, nor in men with frontal lobe lesions was more impulsive than in healthy controls. Patients with schizophrenia spent the same amount of time as healthy participants on planning their action. Moreover men with frontal lobe lesions dedicated even more time to planning than controls did. However both qualitative and quantitative analysis of performance of the patients confirms the conclusion, that time which was spent on planning was less effective in both clinical groups than in healthy controls. In both clinical groups statistically significant lengthening of ToL task execution time was revealed. It was associated with decreased motor speed in patients, but also with the additional time which was spent on creating a new plan after ineffective initial plan had been implemented.

Decrease in planning ability observed in clinical groups in this study finds wide confirmation in literature, with regard both to patients with schizophrenia [12, 20, 22] and patients with frontal lobe lesions [12, 7, 22, 26]. Conclusions of this study are partially consistent with results of the studies of Shallice [9] and Morris [11], which have shown that deficits of planning may be observed only in men with lesions of the left frontal lobe. Results of this study did not confirm Rushe's [23] suggestion that planning deficit is more severe in patients with schizophrenia than in frontal lobe lesions patients. At the same time they are practically absolutely congruent with the findings of Pantelis [22], who has shown that ability to solve problems which require planning and effectiveness of planning are decreased both in men with schizophrenia and in men with frontal lobe lesions. Moreover his study has also shown that these groups do not differ in planning time from healthy controls and execution time is prolonged in both groups [22].

In clinical practice assumption that decreased scores in neuropsychological tests may prove "organic lesions of the central nervous system", especially of the structures involved in the processes which are examined, is often made [10, 27]. As it was revealed in this study, which shows that men with schizophrenia and men with frontal lobe lesions do not differ significantly in any of the ToL task scores, this kind of reasoning may be misleading. Decrease of the scores in the ToL task may indicate abnormalities of the executive system functioning, as in this study ToL performance differentiate both men with schizophrenia and men with frontal lobe lesions from healthy controls.

However similar decrease of the results in ToL may be associated either with “functional” disorders (f.e. schizophrenia) or “organic” lesions of central nervous system (f.e. frontal lobe lesions). Nevertheless while no significant differences in quantitative scores of ToL were found, some of the different qualitative features of the performance in both groups may be indicated. Only observation of the patient’s behavior during the task, combined with examination of the errors he makes and strategies he applies, as well as supplementing quantitative scores with qualitative analysis may allow to draw conclusions regarding the structure of the executive dysfunction, which is observed and, in some cases, its etiology.

Following limitations of this study should be taken into consideration: the group of patients with frontal lobe lesions was not diagnostically homogenous and the effects of medication on cognitive variables observed in this study were not controlled in clinical groups. Future studies should address this issues and utilize the battery of the tests, which are considered as a “gold” standard for assessment of cognition in patients with schizophrenia [28].

Conclusions

1. In men with schizophrenia and in men with frontal lobe lesions ability to solve problems, which require planning, is decreased. In men with schizophrenia effectiveness of planning is also decreased.
2. The amount of time spent on planning action do not improve its efficiency in men with schizophrenia and in men with frontal lobe lesions.
3. Due to the different presentation of the deficits in both groups, qualitative analysis of the ToL scores should be supplemented with quantitative analysis of patient performance.

Нарушение процессов планирования у мужчин, больных шизофренией или очаговыми повреждениями лобных долей головного мозга

Содержание

Задание. Нарушения процесса планирования у пациентов с повреждением лобных долей мозга были описаны многократно в течение последних десятилетий. Существуют также существенные доводы, чтобы считать, что отклонения в функционировании лобных долей составляют существенный фактор в этиопатогенезе шизофрении. Задаaniem настоящего исследования было сравнение уровня способности планирования у мужчин, больных шизофренией, с очаговыми повреждениями лобных долей мозга и здоровых мужчин.

Метод. В исследованиях приняло участие 90 мужчин, разделенных на 3 группы: больных шизофренией (30 мужчин), с очаговыми повреждениями лобных долей мозга (30 мужчин), и 30 здоровых мужчин, составляющих контрольную группу. Способность планирования была оцениваема при использовании клинической пробы на основных Теста лондонской башни (ТЛБ).

Результаты. Отдельные показатели ТЛБ отличали мужчин, больных шизофренией от здоровых мужчин (число разрешенных заданий $p < 0,001$, число правильных решений: $p < 0,05$. Время действия: $p < 0,001$), а также мужчин с очаговыми повреждениями лобных долей мозга от здоровых мужчин. (число заданий с правильным решением: $p < 0,001$, время планирования $p < 0,05$, время действия: $p < 0,001$). Одновременно отмечен ряд статистически существенных

различий между мужчинами, больными шизофренией и мужчинами с очаговым повреждением лобных долей мозга в радиусе каких либо показателей ТЛБ.

Выводы. У мужчин с повреждением лобных долей мозга, а также мужчин, больных шизофренией наблюдался схожий уровень снижения способности планирования своих действий, а также развязывания своих проблем, требующих планирования. В обеих группах, время посвященное на планирования действия использовалось менее эффективно, чем у здоровых мужчин. Настоящее исследование указывает на факт, что оценка пациента при помощи ТЛБ должна учитывать не только количественные показатели исполнения теста, также и качественное описание типа предпринимаемого планирования.

Ключевые слова: шизофрения, лобные доли мозга, планирование

Störungen im Planungsprozess bei den an Schizophrenie kranken Männern oder mit Verletzung des Frontallappens

Zusammenfassung

Ziel. Störungen im Planungsprozess bei den Männern mit der Schädigung der Frontallappen wurden mehrmals in den letzten Jahrzehnten beschrieben. Es wird auch angenommen, dass die Unrichtigkeit bei der Funktion der Frontallappen ein signifikanter Faktor in der Ätiopathogenese der Schizophrenie ist. Das Ziel der vorliegenden Studie war der Vergleich der Fähigkeiten der Planung bei den Männern, die an Schizophrenie krank sind, Männern mit der Verletzung im Frontallappen und bei den gesunden Männern.

Methode. An die Studie wurden insgesamt 90 Männer eingeschlossen, die in drei Gruppen geteilt wurden: an Schizophrenie kranke Männer (n=30), Männer mit Verletzung der Frontallappen (n=30), gesunde Männer (n=30), die eine Kontrollgruppe bildeten. Die Fähigkeit, zu planen, wurde mit Hilfe einer klinischen Probe bewertet, die sich auf den Turm von London (Tower of London - TWL) – Planungstest stützt.

Ergebnisse. Die einzelnen Indexe von TWL unterschieden die an Schizophrenie kranken Männer von den gesunden Männern (Die Zahl der gelösten Aufgaben: $p < 0,01$; Die Zahl der korrekten Aufgaben: $p < 0,05$; Handlungszeit: $p < 0,001$) und die Männer mit der Verletzung der Frontallappen von den gesunden Männern (Die Zahl der gelösten Aufgaben: $p < 0,001$; Planungszeit: $p < 0,05$; Handlungszeit: $p < 0,001$). Gleichzeitig wurden keine statistisch signifikanten Unterschiede zwischen den an Schizophrenie kranken Männern und den Männern mit der Verletzung der Frontallappen im Bereich der TWL-Indexe nachgewiesen.

Schlussfolgerungen. Bei den Männern mit der Verletzung der Frontallappen und bei den Männern, die an Schizophrenie krank sind, kann man eine ähnliche Senkung der Planungsfähigkeiten, und Lösung der Probleme, für die die Planung notwendig ist. In beiden Gruppen wird die für die geplanten Tätigkeiten gewidmete Zeit weniger effektiv genutzt als bei den gesunden Männern. Die vorliegende Studie zeigt, dass die Bewertung des Patienten mittels TWL – Test nicht nur quantitative Indexe bei der Ausführung des Tests berücksichtigen soll, sondern auch eine qualitative Beschreibung der Art der durch sie vorgenommenen Tätigkeiten.

Schlüsselwörter: Schizophrenie, Frontallappen, Planung

Les troubles de la planification chez les hommes souffrant de la schizophrénie ou avec les lésions des lobes frontaux

Résumé

Objectif. Depuis les dernières décades on décrit souvent les troubles de la planification chez les patients avec les lésions des lobes frontaux. Il y a aussi des raisons pour penser que ces dysfonctions des lobes frontaux jouent un rôle important dans la pathogénie de la schizophrénie. Ce travail vise à comparer le niveau de la planification des hommes schizophrènes, des hommes avec des lésions des lobes frontaux et des hommes sains.

Méthode. On examine 90 hommes : souffrant de la schizophrénie (n=30), avec les lésions des lobes frontaux (n=30), hommes sains (n=30). Leur capacité de la planification est examinée dans l'essai clinique basé sur les testes de Tower of London (ToL).

Résultats. On note l'existence de grandes différences dans les groupes des patients schizophrènes et des hommes sains : testes exécutés - $p < 0,01$; testes biens exécutés - $p < 0,05$; temps d'exécution : $p < 0,001$; il en est de même dans les groupes des hommes avec les lésions des lobes frontaux et les hommes sains : testes exécutés : $p < 0,001$; temps de penser : $p < 0,05$; temps d'exécution : $p < 0,001$. Et on n'observe pas de ces différences dans les groupes des schizophrènes et des hommes avec les lésions des lobes frontaux.

Conclusions. On observe les mêmes déficits des capacités de planifier et de résoudre les problèmes dans les groupes des schizophrènes et des hommes avec des lésions des lobes frontaux. Ces deux groupes exigent aussi plus de temps pour penser que les hommes sains. Ce travail suggère encore que l'examen du patient avec Tower of London exige non seulement l'analyse quantitative des indices mais aussi l'analyse qualitative.

Mots clés : schizophrénie, lobe frontal, planification

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